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**Report
Project No. 60128**

**Remedial Investigation
WRR RI/FS Site
Columbia City, Indiana
Volume I of III**

Prepared for:
WRR RI/FS PRP Group

Prepared by:
**Warzyn Engineering Inc.
Chicago, Illinois**

June 1989

FINAL
REMEDIAL INVESTIGATION REPORT
WAYNE RECLAMATION AND RECYCLING, INC.
COLUMBIA CITY, INDIANA

Prepared for:

WRR RI/FS PRP Group

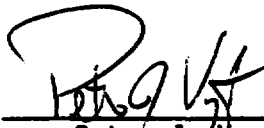
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EXECUTIVE SUMMARY

A two-phased Remedial Investigation (RI) has been completed at the Wayne Reclamation and Recycling, Inc. (WRR) in Columbia City, Indiana. The RI was performed by Warzyn Engineering Inc. (Warzyn) for the WRR Potentially Responsible Parties (PRPs). The RI has been conducted in accordance with planning documents which were originally drafted for the United States Environmental Protection Agency (EPA) by a contractor, later revised by Warzyn and then approved by the EPA. This RI Report is submitted in partial fulfillment of the requirements of Paragraph III of Administrative Order By Consent V-W-87-C-018 dated August 14, 1987.

The WRR Site is located in central Whitley County, approximately 20 miles northwest of Fort Wayne, Indiana. The approximately 30 acre site, located on the southeast edge of the Columbia City limits, is bounded on the south and east by the Blue River. It includes approximately 20 acres currently owned by WRR, 6 acres in the north which WRR sold to Holmes & Co. in 1982, and 4 acres on the west owned by Columbia City (Figure 3).

The site can be divided into three major areas; the southeast portion designated as the lower flood plain, the northeast portion as an old city landfill area, and the central and west portion being the uplands (Figure 3). The lower flood plain includes the areas which are sometimes identified as the "freshwater pond", "oil decanting pit", "tar pit", "sludge ravine", "discolored area", and "acid pit". The old city landfill is in the northeast part of the site and includes an area sometimes identified as the "ink sludge area". The upland area includes the recently closed WRR office buildings.

Phase I field activities were conducted at the WRR Site between February 22, 1988 and March 24, 1988. Phase II field investigations were conducted between July 25, 1988 and September 13, 1988. Field aspects of the investigation included: 1) surveying and mapping the site, 2) conducting a subsurface investigation, 3) excavating test pits, 4) constructing monitoring wells, 5) collecting representative samples of surface soils, surface water, sediment, and groundwater, and 6) conducting aquifer tests. The RI was designed to identify the contaminated media and determine the extent and character of the contamination in those media. The objectives of the project included: collecting data to characterize the natural system, conducting a groundwater assessment, completing a risk assessment, and developing an adequate data base for performing a feasibility study (FS).



WRR began operating an oil reclamation business and waste hauling business at the site in 1975. Investigations by the Indiana State Board of Health starting in 1980 revealed that WRR had illegally disposed of wastes of at the site. In 1982, WRR and one of its principals, Wayne Brockman, pleaded guilty to illegal "depositing of contaminants" and filing false hauler reports. Since 1975, WRR has handled at the site: zinc plating wastes; barrels of dried ink; sludges containing copper, nickel, cadmium, chromium, and cyanide and waste oil and solvents.

As of April 1989, WRR is reportedly not operating an oil hauling and storage business on the west part of the site. The source of drinking water for the WRR facility is the Central Water System provided by the City of Columbia City. The closed Columbia City landfill is located to the north of the east half of the site. The southeast part of the site was apparently the location of the majority of past illegal dumping. Several clean-up projects have occurred at the site. In 1986 and 1987, a removal action was conducted pursuant to an EPA issued Administrative Order by Consent dated July 10, 1986. Drums at the site were excavated, sampled, tested and removed; and liquids, sludges, and/or contaminated soils were excavated and removed from the so called "oil decanting pit", "sludge ravine", "tar pit" and "buried barrel area". Additional removal was conducted in 1988 pursuant to an Administrative Order issued by the EPA on February 17, 1988 and modified on March 29, 1988. This work consisted of the removal of more drums; the excavation and off-site disposal of materials from the so called "acid area", "discolored area", "ink sludge area", and "sludge ravine", and the removal and off-site disposal of the contents of 23 horizontal tanks.

Altogether, previous removal actions have resulted in the removal of more than 13,000 tons of material from the WRR Site. With the exception of the "discolored area", these removal actions have removed the majority of contaminated materials in the known disposal areas on the WRR site. At the "discolored area", the method of deposition seemed to be random spillage or leakage. Based on visual observations of the sidewalls of the excavation, residual waste exists primarily to the east and north of the "discolored area". There are also portions of the south and west side walls where contamination was observed. However, the remaining material would probably be better characterized as contaminated soil rather than waste. For purposes of the RI, these materials are referred to as Soil/Waste.



The WRR Site is located on top of about 200 feet of unconsolidated glacial materials which overlie a shale and dolomite bedrock. The glacial materials are primarily outwash deposits consisting of alternating layers of sand, silt and silty clay. Two separate aquifers have been identified beneath the site: an upper water table aquifer, and a lower confined aquifer. The upper aquifer is not known to be used as a water supply source, but the lower aquifer is the major water resource for Columbia City and the surrounding population. Columbia City's municipal well field is located adjacent to the northern limit of the east half of the WRR Site, and one of two city wells is pumped approximately 8 to 10 hours per day.

Groundwater flow in the upper aquifer is from west to east. In general, groundwater water elevations indicate that the upper aquifer is recharged west of the site, and discharges to the Blue River along the east and south boundary of the site. Average linear groundwater seepage rates are on the order of one foot per day.

In the lower aquifer, the regional hydraulic gradient indicates that natural groundwater flow is from northwest to southeast, thus away from the city wells. The regional gradient was measured at 0.0015 ft/ft, sloping to the southeast when the city wells have not been used for 12 hours. However, pumping the wells has the potential to reverse the horizontal hydraulic gradient in the lower aquifer. After 8 hours of pumping, the gradient beneath the site was 0.0011 ft/ft, sloping from south to north toward the well. (These values are thought to be practical maximum values.) The intensity of the regional gradient to the southeast is about 30 percent higher than the gradient beneath the site caused by pumping. In addition, at current water demands, the city wells are utilized less than 50 percent of the time. As a result, the average gradient is away from the city well field, with the regional gradient to the southeast. On a daily basis, groundwater migration beneath the site could be described as "taking three steps toward and four steps away" from the city wells field.

Vertical hydraulic gradients were also observed to reverse between pumping and non-pumping phases. After 12 hours of recovery, an upward gradient was measured between the lower and the upper aquifer. After 8 hours of pumping, the vertical gradient was downward. The maximum downward gradient was two to four times greater than the maximum upward gradient, suggesting that there is a potential for leakage from the upper to the lower aquifer. Considering only the potential for downward migration, it is estimated that the maximum leakage volume from the upper to lower aquifer for the entire 30-acre WRR

Site is on the order of 8 gallons per minute, during the time when city pump is operating at 1500 gallons per minute. Therefore the dilution factor would be approximately 190:1 (1500/8).

Sampling and chemical analysis of soils, waste, groundwater, surface water and sediments were performed at the WRR Site.

To assist in the evaluation of the extent and migration of hazardous substances at the site, similar types of compounds have been grouped together (Table 13). Chlorinated ethenes and to a lesser extent chlorinated ethanes and toluene were the predominant group of organic contaminants, occurring in all discrete media. In general, chlorinated ethene concentrations increased with depth. While low levels (<200 ug/kg) of chlorinated ethenes were detected in many areas of the site soil, the majority of the high levels were detected in a few areas of the site:

- o At the location of SB-7/MW9, elevated levels of volatile organics were detected during Phase I. Subsequent sampling in Phase II showed that the lateral and vertical extent of soil contamination in the area is probably limited. Elevated levels of volatile organics in groundwater were detected in the monitoring well at this location; however, its extent is also limited because groundwater in the area would move directly south and discharge to the river. Current testing of surface water samples downstream of this area do not detect any significant measurable impact on the river.
- o At the location of SB-40/MW14S, a similar situation occurs. Visual observations of surface soils in the area suggest that the lateral extent of this contamination may also be limited.
- o At the location of SB-2/MW7S, low levels of volatile organics (primarily tetrachloroethene and trichloroethene) were detected during Phase I. There is a limited area of contamination visible at the surface in this vicinity (there are also small patches of contamination visible at the surface in the vicinity of SB-19). Subsequent sampling in Phase II did not detect any significant sources of volatile organics in the subsoils. Groundwater in this area contains elevated levels of 1,2-dichloroethene. It is possible that the tetrachloroethene and trichloroethene detected in the subsoils are degrading to 1,2-dichloroethene. The lateral extent of groundwater contamination may be limited based on the detection of only vinyl chloride in MW4 located approximately 200 feet downgradient.

- o In several areas in the southeast area of the site, high levels of volatile organics were found. The wide scatter in total chlorinated ethene concentrations, even for borings located very close to each other (i.e. SB-36 and SB-24; SB-12 and SB-32) suggests random spillage as opposed to large scale dumping. In addition, the removal action at the site in 1988 caused the removal of a significant volume of soil from this area (Figure 5). In particular, contaminated soils from around MW3S, SB-12, and SB-36 have been removed. Groundwater immediately downgradient of the contaminated soils also contained elevated volatile organics (i.e. MW3S, MW10S). However, the data show that migration of volatile organics may be limited. For instance, when the results of total chlorinated ethenes from MW10S (61,500 ug/L) are compared to the results from MW11S (48 ug/L), located 250 feet downgradient, it is apparent that there may be either very little migration of contaminants with groundwater flow or very high attenuation or degradation occurring. It appears that some volatile organic compounds have migrated through groundwater to the sediment and surface water of the Blue River. The total chlorinated ethenes detected in surface water in the river were below the contract required quantitation limit (CRQL); total chlorinated ethenes detected in river sediments were near the CRQL at two locations (SD-4 and SD-5) and were detected at 1,230 ug/kg at SD-3.

Phthalates were frequently detected in all the discrete media; however, concentrations and distribution showed little correlation within and between media.

The distribution of PAHs at the Site was very limited and generally located in the upper 2 ft of the soils. The analytical results indicate at least two localized area of elevated PAH (SB-18 and SB-20) concentration on-site, but PAHs were not detected below a depth of six feet. No appreciable PAH concentrations were detected in groundwater, surface water or sediment samples.

Several inorganic parameters were detected in on-site soils at concentrations above what would be considered as the common range for "natural soils." Of the metals group magnesium, cadmium, copper, zinc and lead were detected at levels above these common ranges in subsurface soils. In general, the

elevated levels of these compounds coincided with the areas described above for organic compounds. Metals were usually detected in highest concentrations in the top two feet of soils. However, one apparently isolated area of considerably high concentrations of these elements was detected approximately midway between the freshwater pond and the northern boundary of the site (SB-17).

Aluminum, barium, manganese and arsenic were the only inorganic constituents detected in groundwater at concentrations above expected levels for trace metals. As with the organic compounds, the extent of migration may be limited.

Elevated total cyanide concentrations were detected in surface and upper soil boring samples. The higher levels of cyanide were not detected outside of the areas discussed in the dot list above. Total cyanide concentrations in groundwater were not excessively high.

Concentrations of inorganic parameters in surface water and sediments from the Blue River adjacent to the Site were not significantly above those upstream from the Site boundary, with the possible exception of copper and zinc in sediments. A slight increase in cyanide concentrations was observed adjacent to the site as compared to upstream concentrations. Concentrations of inorganic parameters in on-site surface waters and sediments were elevated in the vicinity of SW-9, SW-10, SW-11, and SW-12.

The distribution of contaminants in on-site soils affects current and potential migration to other media. Contaminants currently at or near the surface and adsorbed to soil particulates (metals, total cyanide, PAHs) are most likely to migrate with surface water runoff and erosion and to a lesser extent with airborne dust. However, during normal runoff conditions, migration would be to the center of the southeast area as opposed to off-site via the Blue River with the exception of one small low area near the collapsed WRR garage. Future potential for the migration of site contaminants into the Blue River as a result of surface water runoff and/or erosion would only occur during flood conditions.

Contaminants currently in subsurface soils (chlorinated ethenes, chlorinated ethanes and toluene) migrate through the soil phase and into the water table with groundwater recharge. This process appears to have taken place at the Site. The predominant site-related contaminants in the upper aquifer are the chlorinated ethenes, chlorinated ethanes and, to a lesser extent, toluene.



Most of the contamination is adjacent to the Blue River and will probably migrate towards the river. However, current data suggest that no large scale migration of contaminants to the river is occurring. Although, chlorinated ethenes have been detected in the Blue River, the concentrations at all sample locations were below the contract required quantitation limit. Although there is the potential for migration beneath the river to the east, the attenuation or degradation of compounds that occurs between MW3S and MW11S may suggest that contamination may not be detected east of the river. The analytical data indicate that the aquitard at the base of the upper aquifer appears to limit downward migration to the lower aquifer.

The attenuation of contaminants in soils and groundwater is controlled by many physical, chemical and biological processes. Currently biochemical degradation of the chlorinated ethenes and chlorinated ethanes appears to be taking place. The occurrence of clay and silt in area soils enhances the potential attenuation of site-related contaminants through adsorption.

An assessment of public and environmental health risks was conducted for the WRR Site. The process was made up of four components as suggested in the Superfund Public Health Evaluation Manual (U.S. EPA, 1986): indicator chemical selection, toxicity evaluation, exposure assessment and risk characterization.

As a result of the indicator selection process used, vinyl chloride, 1,2-dichloroethene, trichloroethene, toluene, bis(2-ethylhexyl)phthalate, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), cadmium, chromium, nickel, arsenic, cyanide, and zinc were considered to represent the greatest potential public health threat of the contaminants detected at the site.

Two exposure scenarios were evaluated in the baseline risk assessment: current site (use) conditions and plausible future site (use) conditions. The current use scenario evaluated exposures to potential trespassers on-site. The site is zoned for industrial use, thus, for future site conditions, it was assumed that the site may be developed and that construction workers would be exposed to surface and subsurface contaminants. It was also assumed for the future use scenario that Municipal Well #8 may be contaminated (i.e., drawing groundwater from the contaminated aquifer) under an increased demand for its use as the area develops. In addition, assumptions were applied to estimate potential risk should groundwater contaminants migrate to existing private wells.

Both current and future use scenarios were based on the premise that no action would be taken to mitigate release of contaminants from the site and no restrictions would be imposed.

Based on current use conditions at the site, no risks were identified through exposure to contaminated groundwater. Under current conditions, only trespassers were identified as incurring some potential risk, through exposure to contaminated soils. Actual risk to trespassers is likely to be much lower than the calculated risk because the contaminants that contributed to the majority of the risk occur in discrete, localized areas. In addition, the number of individuals likely to trespass on the site is probably very low, thus further reducing the potential for exposure at the site.

Under the assumptions made to assess future site conditions, risks from exposure to contaminated soils were estimated for construction workers potentially working at the site in the future. As described above for site trespassers, actual risks associated with this activity would be very low because areas of contaminated soils are localized. In addition, the number of exposed individuals would be small, thus reducing the probability of contact. Under future site assumptions, risks were estimated for users of municipal water and users of private well water. However, these risks would be realized only if there were to be a dramatic increase in the water usage by Columbia City (i.e. pumping would probably have to increase to 16 hours a day from the current 8 hours a day). In addition, the assumption that the contaminant levels at the municipal well result from simply the dilution of contaminants (by a ratio of downward flow from the upper aquifer to total flow in the municipal well) is conservative. The assumptions used in the endangerment assessment are also very conservative. The sum of all these factors may result in the actual risk being lower than the calculated risk.

The risk characterization section of Chapter 6.0 provides a detailed description of potential risks to current and future users based on the conditions and assumptions applied in this assessment. Because the final health risk estimates were ascertained by comparing estimated exposure doses (with uncertainties) with appropriate reference doses (with uncertainties), the risk estimates should only be viewed as approximate. The risks calculated should be viewed on a relative rather than actual basis.

A summary of the estimated lifetime cancer risks associated with this site can be found in Table 49.



**REMEDIAL INVESTIGATION REPORT
WAYNE RECLAMATION AND RECYCLING, INC.
COLUMBIA CITY, INDIANA**

**FINAL
JUNE 1, 1989**

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1.0 INTRODUCTION

Warzyn Engineering Inc. (Warzyn) was retained by the Wayne Reclamation and Recycling, Inc. (WRR) PRP Steering Committee (PRP) to perform the Remedial Investigation (RI) at the WRR site in Columbia City, Indiana. The planning documents for this RI were originally prepared by a contractor to the United States Environmental Protection Agency (EPA). The documents were modified during negotiations among Warzyn, the PRP's and EPA. Work conducted as a part of the RI was completed in accordance with planning documents that had been approved by EPA. This RI Report is submitted in partial fulfillment of the requirements of Paragraph III of Administrative Order By Consent V-W-87-C-018, dated August 14, 1987 (Consent Order).

1.1 Purpose of Remedial Investigation

This RI was conducted to provide the data necessary for the completion of a Feasibility Study (FS) which will identify, evaluate, and prepare conceptual designs for remedial alternatives at the WRR Site. The RI data collection activities were designed to meet the following objectives:

- o To confirm or deny expected locations of hazardous substances on the site;
- o To evaluate locations of suspected contamination on the site;
- o To determine the extent and character of hazardous and/or toxic materials present on the site, including the horizontal and vertical distribution of potential sources of contamination;
- o To determine the physical and chemical properties of each identified source area containing hazardous and/or toxic materials;
- o To determine the nature and extent of actual and potential releases from source areas;
- o To characterize the known and potential pathways for release of contaminants from source areas. Characterization of pathways includes evaluation of physical properties governing transport within given pathways; and



- o To determine and document the type, extent and magnitude of contamination of media by hazardous substances, as necessary, to assess endangerment to human health and the environment and to perform a FS.

The Final Work Plan for the WRR Site defined 11 tasks to be completed during the RI:

- o Task 1 - Preparation of Project Operation Plan (POP),
- o Task 2 - Study Area Surveys
- o Task 3 - Source Characterization
- o Task 4 - Site Characterization
- o Task 5 - Feasibility Study Testing
- o Task 6 - Data Validation
- o Task 7 - Contaminant Pathway and Transport Evaluation
- o Task 8 - Public Health Evaluation
- o Task 9 - Remedial Investigation Report
- o Task 10- Quality Assurance/Quality Control
- o Task 11- Investigation of Anomaly Areas Determined During the Geophysical Survey

The scope of work for Task 1 had previously been completed with the acceptance by EPA of the Final Work Plan, Addendum No. 1 to the Final Work Plan (Phase II Scope of Work), Quality Assurance Project Plan (QAPP), and QAPP-Addendum No. 1. No work was required under Task 6. Submittal of this report completes the scope of work for Tasks 2 through 8, 10, and 11. It also serves as partial completion of Task 9.

To meet the RI objectives, a field investigation was conducted in two phases completing the following tasks.

- o Drilling of soil borings and collection of soil samples at various locations across the site. Many of the borings were in areas where waste had been dumped;
- o Test pit excavations into known and suspected disposal areas;
- o Chemical and physical testing of selected soil samples from borings;
- o Installation of monitoring wells at the site perimeter and within the active site area;
- o Performance of aquifer tests by slug test and pumping test methods;

- o Collection and evaluation of water level readings at monitoring wells and surface water staff gages;
- o Collection and analysis of surface water and sediment samples;
- o Collection and analysis of groundwater samples from groundwater monitoring wells, municipal water supply wells, and private water supply wells; and
- o Performance of a survey to locate and obtain elevations of all sampling locations, including soil samples, waste samples, surface water samples, sediment samples, and groundwater samples.

Sampling and analysis of 21 horizontal tanks located on-site were deleted from the Work Plan because this work was conducted as a part of the 1988 EPA Removal Order.

1.2 Site Background

1.2.1 Site Description

The WRR Site is located in central Whitley County, approximately 20 miles northwest of Fort Wayne, Indiana (Figure 1). It is situated in the northern half of the southeast quarter of Section 11, T31N R90W (Figure 2). The approximately 30 acre site, located on the southeast edge of the Columbia City limits, is bounded on the south and east by the Blue River. It includes approximately 20 acres currently owned by WRR, 6 acres in the north which WRR sold to Holmes & Co. in 1982, and 4 acres on the west owned by Columbia City (Figure 3).

The site can be divided into three major areas; the southeast portion designated as the lower flood plain, the northeast portion as an old city landfill area, and the central and west portion being the uplands (Figure 3). The lower flood plain includes the areas which are sometimes identified as the "freshwater pond", "oil decanting pit", "tar pit", "sludge ravine", "discolored area", and "acid pit". The old city landfill is in the northeast part of the site and includes an area sometimes identified as the "ink sludge area". The upland area includes the still active WRR office buildings.

The WRR site is located within the Wabash River Drainage Basin and partly within the 100 year flood plain of the Blue River. Blue River frontage at the site extends for 725 feet on the east edge, and 1600 feet along the south edge.



1.2.2 Site History

In 1975, WRR purchased approximately 25 acres of land on the southeast edge of Columbia City including a 13.6 acre portion that Columbia City owned since 1953. WRR and its division, Wayne Waste Oil, began operating an oil reclamation business at the site in 1975. It was granted a license to haul liquid industrial wastes by the Indiana Pollution Control Board in 1976. In 1982, WRR sold about 6 acres on the northern part of its property to Holmes & Co. Table 1 is a summary of key dates and events which occurred at the site prior to and during the company's operation.

In 1980 the Indiana State Board of Health (ISBH) began investigating the WRR site as a result of reports from a former employee of WRR that hazardous wastes were being illegally disposed of at the site. ISBH determined that between February 1979 and May 1980, WRR filed hauler reports stating that it had disposed of 250,000 gallons of sludge at the Williams County landfill in Bryan, Ohio. However, the landfill had not received any waste shipments from WRR during that time.

In 1982, WRR and one of its principals, Wayne Brockman, pleaded guilty to illegal "depositing of contaminants" and filing false hauler reports. They were required to pay a fine, to fund a risk assessment of the site, and to pay for cleanup. The risk assessment was conducted by Beranek Associates, Inc. (Beranek, 1984) between March 1983 and June 1984, and showed that little potential exists for groundwater contamination or impact on the city drinking water supply, provided that the use of city well 8 is limited. Furthermore, the risk assessment indicated that potential risk to the Blue River was low, except in the instance of a severe flood which could wash chemicals from the "sludge ravine" into the river. WRR did not perform the cleanup required under its guilty plea.

1.2.3 Cleanup Activities at the Site

Prior to and subsequent to development of the Work Plan for the RI, several discrete disposal areas were identified at the site. Each area was given a descriptive name by the EPA for the purpose of defining the location of the area. The descriptive names were not necessarily representative of the physical or chemical nature of the materials found in the area. The known disposal areas consisted of:

- o "sludge ravine"
- o "oil decanting pit"
- o "tar pit"
- o "buried barrel area"



- o "acid area"
- o "discolored area"
- o "ink sludge area"

The EPA issued an Administrative Order by Consent dated July 10, 1986, which required the respondents to: install temporary fencing and warning signs; remove drums located on the surface of the site; excavate and remove certain buried drums; sample and test the contents of the removed drums; excavate liquids, sludges, and/or contaminated soil in the so-called "oil decanting pit", "sludge ravine", "tar pit", and "buried barrel area"; and dispose of all such removed materials. This work was performed from late summer, 1986, to fall of 1987 and consisted of:

- o excavating and disposing of approximately 5600 tons of material from the "sludge ravine";
- o excavating and disposing of approximately 1100 tons of material from the "oil decanting pit";
- o excavating and disposing of approximately 90 tons of material from the "tar pit"; and
- o removing, testing and disposing of the contents of 215 55-gallon drums and 750 tons of soil from the "buried barrel area" and backfilling the area with off-site borrow.

Further removal work was performed by four companies named in an Administrative Order issued by EPA on February 17, 1988, and modified on March 29, 1988 and May 23, 1988. The work performed pursuant to the second Order was conducted from May 1988 through March, 1989, and included: removing, testing, and disposing of the contents of 125 additional drums; excavating and disposing of 5400 tons of contaminated soil from the so-called "acid area", "discolored area", "ink sludge area", and "sludge ravine"; removing and disposing of the contents, including oils and solvents, in 23 horizontal tanks; installing chain link fencing around the so-called "oil decanting pit", "sludge ravine", and "discolored area" and backfilling the "acid pit" and "ink sludge area" with off-site borrow.

Altogether, previous removal actions have resulted in the removal of more than 13,000 tons of material from the site. With the exception of the "discolored area", these removal actions have removed the majority of contaminated materials in the known disposal areas on the WRR Site. At the "discolored area", the method of deposition seemed to be random spillage or

leakage. Based on visual observations of the sidewalls of the excavation, residual waste exists primarily to the east and north of the "discolored area". There are also portions of the south and west side walls where contamination was observed. However, the remaining material would probably be better characterized as contaminated soil rather than waste. For purposes of the RI Report, these materials will be referred to as Soil/Waste.

1.3 Organization of RI Report

This RI Report is comprised of 3 volumes. The volumes may be referenced by their respective contents which are as follows:

Volume I	Text with Tables and Figures
Volume II	Appendices
Volume III	Appendices

The report describes the performance and findings of the RI. Data collected prior to initiation of the RI have been considered, however, the majority of the analysis of site conditions relies on data collected as part of the RI. Section 2.0 presents the details of the field procedures used to collect the data. Section 3.0 contains a detailed characterization of the setting of the site, including topography, geology, hydrology, and hydrogeology. Section 4.0 contains a description of the nature and extent of contamination on the site. For the purposes of clarity, the discussion is broken into discussions about each media; Waste/Soils, Groundwater, Surface Water, and Sediment. Each section also contains a discussion of the chemical similarities of the various media.

The actual or potential migration of contaminants is described in Section 5.0 and the transport and transfer of contaminants within and between media are also evaluated in Section 5.0. Section 6.0 presents a Baseline Risk Assessment which is based on the available RI data. The summary of the RI and conclusions reached are presented in Section 7.0. The references cited throughout the report are included in Section 8.0.

2.0 REMEDIAL INVESTIGATION ACTIVITIES

The RI was planned to determine the nature and extent of contamination at the WRR Site in the media of soils, surface water, sediment, and groundwater and provide the necessary information for conducting an FS. Field investigations were conducted at the WRR Site in two phases. The general goal of Phase I was to identify the contaminated areas and media; the general goal of Phase II was to determine the extent and character of the contamination in the areas and media identified in Phase I. In both phases, data and information were collected to characterize the natural system, including the geology specific to the site and hydrogeologic regime. Upon completion of the second phase of the investigation, data and information concerning the WRR Site was sufficient to meet these goals.

Phase I field activities were conducted at the site between February 22, 1988 and March 24, 1988. Phase II field investigations were conducted between July 25, 1988 and September 13, 1988. Field aspects of the investigation included: 1) surveying and mapping the site, 2) conducting a subsurface investigation, 3) excavating test pits, 4) constructing monitoring wells, 5) collecting representative samples of surface and subsurface soils, surface water, sediment, and groundwater, and 6) conducting aquifer tests.

The planning documents to conduct this investigation include a Work Plan, a Quality Assurance Project Plan, a Site Health and Safety Plan, and a Sampling and Analysis Plan. The following documents were used by Warzyn to develop the revised planning documents, conduct the site investigation, and produce this RI Report.

- o U.S. EPA, Office of Emergency and Remedial Response, March 1988. Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, OWSER Directive 9355.3-01.
- o U.S. EPA, Region V, December 1985, Preparation of Federal-Lead Remedial Investigation Quality Assurance Project Plans for Region V.
- o U.S. EPA, December 1980. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-500/80.
- o U.S. EPA, June 1986, Data Quality Objectives for the RI/FS Process, Doc. No. 9355.0-7A.



The remainder of this section describes the number, locations and rationale for each task and sampling event conducted at the WRR Site. Detailed procedural descriptions, including Quality Assurance Protocols are included in Appendix A.

2.1 Surveying and Mapping Surface Features.

Abrams Aerial Photography was contracted to photograph the site and develop a base map of the WRR Site. This map was made at a scale of one inch equal to 50 feet with a two-foot contour interval showing site conditions as of May 1988. (The figures have also been reduced to 11 by 17 inch format, providing one inch equal to 100 feet for inclusion in Volume I of the RI Report).

A copy of the aerial photograph has been reproduced as a map (Figure 3) to show the locations of the significant natural and man-made features. It is also used to delineate areas of major investigative effort and to identify the areas in which removal actions were undertaken during two previous remedial actions at the request of the EPA.

Licensed professional surveyors visited the site initially to establish the base grid and field check the aerial mapping. Additional surveys were made at several later dates as additional site activities were completed. These were necessary to establish the horizontal and vertical locations of each sampling point including: monitoring wells, soil borings, surface soil samples, surface water and sediment samples, surface water staff gages, and test pits.

The degree of precision used for each measurement was dependent upon the nature and use of the surveyed point. Test pits, soil, surface water, and sediment sampling points were located to the nearest foot horizontally and the nearest 0.1 foot vertically. Staff gages and monitoring wells, in which precise vertical datum is necessary, were located to the nearest 0.1 foot horizontally and to the nearest 0.01 foot vertically.

Elevations of sampling points were referenced to an on-site datum. The on-site datum was tied into the USGS National Geodetic Vertical Datum by completing an elevation survey to a benchmark located at the bridge over the Blue River at Van Buren Street. A second elevation survey was run to a benchmark located at the bridge over the Blue River at Whitley Street.



Elevations shown in the RI Report can be converted to USGS elevations by subtracting 5.00 feet.

2.2 Subsurface Investigation by Soil Borings.

2.2.1 Phase I Soil Borings.

Exploratory drilling was conducted in both phases of the investigation. The goals of the drilling included:

- o collecting samples for chemical analysis to determine the character, magnitude and extent of contamination across the site;
- o collecting soil samples for geotechnical analysis to aid in the hydrogeologic characterization of the site;
- o defining stratigraphic sequences beneath the site; and
- o making the boreholes for placement of monitoring wells.

A summary of sampling locations is shown on Figure 4. The twenty-six Phase I soil borings (SB-1 through SB-26) were drilled on-site between February 22 and March 1, 1988 (Figure 5). A Warzyn professional was present at each boring location during the drilling to keep a log of the geologic materials encountered and to collect representative samples for geotechnical or chemical laboratory analysis. A standard two-inch inside diameter (I.D.) 18" long split-spoon sampler was used to collect the subsurface soil samples. Split-spoon samples were normally collected at the following intervals.

- o Zero to 18 inch depth;
- o continuously from the surface to 10 feet for soil borings for chemical analysis sampling, and at 2.5 foot intervals to 10 feet for monitoring well borings; and
- o at five-foot intervals from 10 feet to the termination of the boring.

A portable photoionization detector (HNU) was used to field screen for the presence of volatile organics in each split-spoon sample, as soon as the split-spoon was opened. Three samples were collected from each boring for chemical analysis, one from the upper two-feet, a second from the two to six foot interval and one from the six to ten foot interval. The sample for each interval was selected from that portion of the split-spoon sample which

appeared, either visually or by HNu reading, to be the most highly contaminated. If no contamination was evident, a composite sample was made from the entire interval. Also, a representative portion from each split-spoon sample was kept for geotechnical analysis.

In general, the Phase I soil borings which were made primarily to collect soil samples for analytical testing were drilled to 10 feet below ground surface. Eleven of the soil borings were drilled deeper to allow for the installation of shallow monitoring wells (MW-1S to MW-11S). Table 2 shows the correspondence between boring number and monitoring well number.

2.2.2 Phase II Soil Borings.

Phase II soil borings were performed between July 25 and August 16, 1988. The purposes of the Phase II soil borings were to determine the lateral and vertical extent of soil contamination in six areas (described below) of the site identified during Phase I, and to confirm or deny the existence of anomalies detected during Phase I. The Phase II soil boring program consisted of:

- o Drilling 22 auger probes (SB-A to SB-V) to a depth of 10 feet in the southeast area of the site (Figure 5). These borings were drilled on a 50 foot center grid pattern over the southeast area. At each auger probe location, the subsurface soil was classified visually for soil type and visual contamination, and screened with a portable HNu photoionization detector. Findings were recorded on detailed boring logs included in Appendix B.

Borings C, D, E, F, G, H, L, N, S and U had HNu levels greater than 100 parts per million (ppm) but no visual contamination was observed. Borings I, J, K, M and V had HNu readings between 3 and 30 ppm and also had no visual contamination. Borings A, B, O, P, Q, R and T had less than 1 ppm detected.

Based on these findings it appears that contamination in the southeast area is primarily limited to a triangular shaped area with the points being Borings S, U and D. Because of the lack of visual contamination, the HNu readings may suggest the migration of volatiles through the permeable material found in the southeast area soils. It appears that the contamination may be from random sources spilled or dumped in discrete areas. The approximate limits of these discrete areas cannot be well defined. The auger probes were used to select the locations of soil borings to be split-spoon sampled in Phase II. No auger

probes were drilled in the "discolored area" because this area was to be excavated and disposed of off-site.

- o Based on the results of the auger probes, drilling 12 soil borings (SB-027 to SB-038) in the southeast area of the site to a depth of 10 feet with continuous split-spoon sampling conducted on 2 foot centers from 2 feet to 10 feet. Two samples were collected from each boring to be analyzed for Target Compound List Volatile Organic Compounds (VOC). VOC's were to be used simply as indicators of the extent of contamination.
- o Drilling a soil boring at the location of SB-17 to confirm or deny the presence of elevated concentrations of metals.
- o Drilling a soil boring at the location of SB-18 to confirm or deny the presence of elevated concentrations of polycyclic aromatic hydrocarbons (PAH).
- o Drilling five soil borings to a depth of 10 feet in the vicinity of SB-7, and collecting six soil samples for analysis of VOC.
- o Drilling three soil borings to a depth of 10 feet in the vicinity of SB-2 and collecting six soil samples for analysis of VOC.

A Warzyn professional was present at each boring location during the drilling to keep the boring log and collect samples as in Phase I. Seven of the borings were instrumented as Phase II monitoring wells. Table 2 shows the correspondence between boring number and monitoring well number. The sampling procedures including Quality Assurance protocols, sample handling, preservation, and shipping are described in Appendix A. Soil boring logs are presented in Appendix B.

Drilling during both Phase I and Phase II was performed by Exploration Technology Inc. (ETI) of Madison, Wisconsin. All drilling and well installation activities were performed under the direct supervision of a Warzyn geologist. The soil samples collected but not submitted for chemical analysis have been temporarily stored at the WRR Site for appropriate handling or disposal when the site is remediated. Twelve samples, selected to represent the two aquifers, the confining layer between them, and vadose zone were submitted to the Warzyn soils laboratory for geotechnical analysis.



2.3 Contaminant Source Investigation by Test Pit Excavation.

Based on the detection of magnetic anomalies during a geophysical survey, EPA suspected that waste was buried in four areas on the WRR Site. On March 23, 1988, test pit excavations were made by backhoe in the four areas where geophysical anomalies were detected in an attempt to locate the suspected buried waste material (Figure 6). Each test pit excavation was performed by personnel equipped in Level B safety gear. Characterization of excavated materials involved visual observations by the field geologist of the general appearance of the excavated material. Refuse (bottles, cans, paper, etc.) was encountered in all four test pits. The refuse was screened with portable monitoring equipment for volatile organics and cyanide by the on-site safety officer continuously during each excavation. No readings above background were recorded. All excavated material was backfilled into each pit upon completion.

2.4 Monitoring Well Construction.

A total of 14 upper aquifer monitoring wells, four upper aquifer piezometers, one well screened in the confining layer between the aquifers, and three lower aquifer wells were constructed during the two-phased RI conducted at the WRR Site. The general objectives of constructing monitoring wells included developing a geologic characterization, supplying access points to measure groundwater elevations at locations in both aquifers, and providing sampling points in each of the aquifers.

2.4.1 Phase I Monitoring Wells.

The 11 Phase I monitoring well locations were selected to provide a general assessment of the groundwater levels and water quality across the WRR Site. The monitoring wells were numbered sequentially from MW-1S to MW-11S; the "S" signifies a shallow well, screened in the upper aquifer. The locations of the wells are shown on Figure 7.

The borehole for each monitoring well was advanced by using 4.25-inch inside diameter (ID) hollow stem augers (HSA) to a depth of approximately 10 feet below the water table. Decontamination procedures are described in Appendix A. The assembled well string was placed in the borehole with the augers still in place. The annular space between the well and the edge of the borehole or auger was backfilled with either red flint filter sand or natural caved formation material or both. The sand pack material around the screen was placed at least one foot above the top of the screen. Following the sand

pack, at least two feet of bentonite pellets were placed around the riser pipe to seal the screened section off from overlying materials. The remainder of annular space was filled with either granular bentonite, powdered bentonite, or a bentonite and cuttings mixture. A five-foot steel locking protective casing was placed over each well and seated in concrete in the annular backfill material. Locks were attached to the protective casing immediately after installation. Well construction details are summarized in the table prefacing Appendix C, and shown graphically on each boring log.

Each well was developed by removing at least ten volumes of water using a stainless steel bailer. The pH and conductivity values were measured periodically during development; water was also noted to become less cloudy and/or silty as development proceeded. Development was considered complete when pH and conductivity values stabilized.

2.4.2 Phase II Monitoring Wells and Piezometers.

Monitoring well construction in Phase II consisted of three additional shallow wells, four non-sampling piezometers, one intermediate depth monitoring well and three lower aquifer monitoring wells. The shallow monitoring wells were numbered sequentially from MW-12S to MW-14S. The piezometers were numbered sequentially from P-1 to P-4. Locations were selected for the three lower aquifer monitoring wells to provide optimal water level and water quality information. Each lower aquifer monitoring well was located adjacent to existing upper aquifer monitoring wells, forming three well nests. They were numbered MW-1D, MW-8D, and MW-13D. At well nest MW-1, a third well was screened at an intermediate depth (I) in the confining layer between the upper and lower aquifers (MW-1I). The locations of the wells are shown on Figure 7. Construction, decontamination, and development procedures are the same as described for Phase I.

To derive additional information about the thickness of the upper aquifer and to locate the confining layer, soil borings were extended to the first clay contact adjacent to the Blue River at two locations, MW-12S and MW-14S. After logging the borehole at these locations, the borings were sealed with bentonite grout, and another shallow water table boring was made for placement of the monitoring well.

The boreholes for the intermediate and deep monitoring wells were advanced by wash rotary technique. Since the shallow subsurface stratigraphy was known from the shallow well constructed at the nest location, drilling was advanced without sampling to the interval directly below the shallow wells depth.

Sampling then continued at five-foot intervals to the final depth of each deep boring/well. Casing was driven and set in the confining layer before drilling into the lower aquifer. Upon completion at a depth of approximately 150 feet, each borehole flushed with potable water to remove drilling fluid.

Water levels collected from the Phase I monitoring wells indicated an anomaly in the vicinity of the fresh water pond, so four piezometers were installed, one on each side of pond. Since the piezometers were not intended for collecting analytical samples, they were constructed with two-inch ID schedule 40, threaded PVC riser pipe with ten-foot No. 10 slot PVC well screens. Boreholes were advanced below the water table, and the piezometers were placed with the screens located to intersect the water table. Other construction and development procedures were the same as used during installation of the shallow monitoring wells.

2.5 Sample Collecting.

2.5.1 Phase I Sampling.

The purpose of the Phase I sampling program was to identify contaminated areas and media. Therefore, all Phase I samples submitted for chemical analysis were tested for EPA Target Compound List (TCL) Volatile Organic Compounds (VOC), Semi-Volatile Organic Compounds (SVOC), Pesticides/PCBs (P/PCB), metals and cyanide. In addition, groundwater samples were tested for three indicator compounds (alkalinity, chloride and sulfate).

2.5.1.1 Phase I Subsurface Soil Samples.

Seventy-four subsurface soil samples were collected during Phase I. In general, three soil samples were collected from each of the 26 soil borings drilled. Samples were submitted from depths of 2, 6 and 10 feet for each borings except the 10 feet samples from borings SB-5, SB-13, SB-15 and SB-21. Soil samples were not collected at depths of 10 feet from SB-5, SB-15 and SB-21 because the samples were below the water table. At SB-13, refuse was encountered at a depth of six feet. Duplicate samples were collected at eight locations; SB003-10, SB005-02, SB006-02, SB010-10, SB012-06, SB014-06, SB017-10, and SB024-06. The quality assurance protocols which were followed are described in Appendix A. Analytical results are included in Appendix J.

2.5.1.2 Surface Soil Samples.

Surface soil sampling was conducted on March 19, 1988, during the Phase I investigation. The six surface soil characterization sampling locations are shown on Figure 8. Five soil samples (SS-1 through SS-5) were collected from areas of visible spills located in the southeast area of the site. A surface soil sample (SS-6) was collected from the road surface near the site entrance. These grab samples were collected with a stainless steel spoon and placed in a stainless steel bowl before being transferred into the appropriate sample containers. Each sample was obtained from the interval between the surface and a depth of one foot. Sampling equipment was decontaminated prior to use as outlined in Appendix A. One field duplicate sample was collected at surface soil sample SS-4. The surface soil samples were shipped the same day to the designated analytical laboratory. The quality assurance protocols which were followed are described in Appendix A. Analytical results are included in Appendix J.

2.5.1.3 Surface Water Sampling.

Thirteen surface water samples were collected on March 17 and 18, 1988. Five samples were collected from surface water bodies on the WRR Site and the remaining sample locations were collected from the Blue River. The five on-site sample locations are as follows (Figure 9):

- o The "freshwater pond" (SW-8 and SW-13),
- o The wetland area where a standing water pond exists (SW-9),
- o The "tar pit" (SW-10),
- o The "sludge ravine" (SW-11), and
- o The "oil decanting pit" (SW-12)

The Blue River was sampled at seven locations (Figure 9). Sampling proceeded from the downstream location to the upstream locations, so that any disturbance during sampling would not affect the next sample. The following summarizes the sampling locations:

- o approximately 300 feet north (upstream) of the north site boundary (SW-1),
- o east of the old city Landfill (SW-2),
- o 400 feet north of the sharp bend in the Blue River (SW-3),

- o at the sharp river bend at the southeast corner of the site (SW-4),
- o 350 feet west of the sharp bend in the Blue River (SW-5),
- o southwest of the storage building (SW-6), and
- o An off-site downstream location approximately 500 ft. west of the western site boundary (SW-7).

All surface water samples were obtained within the upper 1 foot of water surface by using a stainless steel dipper or by immersing the sample container directly into the water. Field duplicate samples were collected at SW-5 and SW-11 locations. All sampling equipment was decontaminated as outlined in Appendix A. Specific conductivity, temperature, and pH were measured in the field at the time of sampling.

2.5.1.4 Sediment Sampling.

Eighteen sediment samples were collected at the same locations as the surface water samples described in Section 2.5.1.2 (Figure 9). Sediments from both the right and left river bank were collected from the Blue River at sample locations SW-1, SW-2, SW-4, and SW-7. Sediment sample SD-14 was collected in a surface runoff pathway near the back of the WRR office building. Sediment sample SD-1 was sampled to determine background levels in the sediments of the Blue River.

The sediment samples were collected using a stainless steel spoon or dipper to a depth of no more than 6 inches. All grab samples were placed in a stainless steel bowl, quickly mixed with a stainless steel spatula or spoon and placed into the appropriate sample jars. Details of sampling equipment, decontamination, and sampling procedures are outlined in Appendix A. Two duplicate sediment samples were collected in the same locations as the surface water sample duplicates (SW-5 and SW-11). All surface water and sediment samples were shipped the same day they were collected to the designated analytical laboratory.

2.5.1.5 Phase I Groundwater Sampling.

Phase I groundwater sampling was conducted between March 14 and 17, 1988; seventeen groundwater samples were collected from wells located at or near the WRR Site (Figure 7). Eleven of these sample locations were from monitoring wells (MW-1S through MW-11S) installed by Warzyn during the Phase I investigation. Another sample location was from existing production well, "PH", located near the WRR office building. This well is no longer in use.



The remaining samples were collected from monitoring wells installed in 1983 by Beranek Associates (MW-83A(S), MW-83A(D), MW-83D and MW-83E). Duplicate samples were collected from monitoring wells MW-2S and MW-7S. The postscripts (S) and (D) in MW-83A do not refer to a shallow or deep well similar to those drilled during the RI.

The sampling procedure at each monitoring well included the following steps: measurement of static groundwater elevation, removal of at least three times the static volume of water, field measurement of pH and conductivity to determine the presence of formation water. After the well had recharged fully from purging, sample volumes were collected in the following order: (1) two 40-ml vials for volatiles, (2) four one-liter amber glass bottles for semi-volatile, pesticide and PCB analysis, and (3) three one-liter polyethylene bottles for cyanide, metals, and indicators analysis. All samples collected for metals analysis were filtered by positive pressure through a 0.45 micron filter within one hour of collection. All required preservatives were added to the metal and cyanide samples within one hour of collection.

Groundwater samples from each of the shallow groundwater monitoring wells were collected using a stainless steel bailer with attached stainless steel cable. Appendix A describes procedures followed during sampling for quality assurance. Field bailer blanks were collected to document the thoroughness of the decontamination procedure. Each sample was shipped to the designated laboratory on the day it was collected. The analytical results are tabulated in Appendix J.

2.5.2 Phase II Sampling.

The purpose of the Phase II sampling was to determine the lateral and vertical extent of contamination identified in Phase I.

2.5.2.1 Phase II Subsurface Soil Samples.

As described in Section 2.2, Phase II soil borings were drilled to investigate five areas of the site. At SB-2, SB-7 and the southeast area of the site, soil samples collected during Phase II were analyzed for VOC. The results of the VOC analysis were intended to determine the lateral and vertical extent of contamination in each area. The samples from SB-017A were analyzed for metals and the samples from SB-18A were analyzed for VOC and semi-volatile compounds.

Duplicate samples were collected from SB-017A-10, SB-017-05 and SB-027-10. All sampling equipment was decontaminated as outlined in Appendix A.

2.5.2.2 Phase II Groundwater Sampling.

Between August 30 and October 28, 1988, 21 groundwater samples were collected from wells located at or near the WRR Site. Sampling and handling procedures were the same as followed during Phase I sampling. Duplicate samples were collected from monitoring wells MW-9S and MW-14S. Locations of on-site wells are shown on Figure 7. During Phase II, groundwater samples were collected from the two Columbia city Municipal Wells and two private residential wells. The locations of municipal and private wells in the vicinity of the site are shown on Figure 10. A summary of construction details for the wells is presented in Appendix D. The rationale for the selection of wells to be sampled was:

- o Municipal Wells No.7 and 8 (Figure 10 locations 2 and 3 are currently in use and therefore samples were collected.
- o Figure 10 location 7 is on-site well PH which was sampled in Rounds I and II and is no longer in use.
- o Figure 10 location 5 was a test well (74A) for a proposed municipal well. It could not be located and may be abandoned.
- o No locations were selected northeast of the site because these wells are not downgradient of the site.
- o Locations 8 and PW (PW-01 and PW-02 respectively) that are south of the site were selected because they were the closest representative downgradient wells. Locations 9, 26 and 40 were not selected because they are in or adjacent to an auto junk yard and or body shop. Location 20 was not selected because it is a bedrock well.

Well pumps were run for at least 15 minutes prior to sampling to purge standing water from the well casing and annulus. Municipal and private well samples were not filtered. Duplicate samples were collected from private well PW-01 and from municipal well MW-01.

All groundwater sampling equipment was decontaminated as outlined in Appendix A. Each sample was shipped to the designated analytical laboratory on the day it was collected.



2.6 Hydrogeologic Field Investigation.

Hydrogeologic information required for the RI included geologic descriptions of the subsurface conditions, surface water and groundwater levels, and hydraulic properties of the aquifers.

2.6.1 Surface Water and Groundwater Levels.

2.6.1.1 Staff Gages.

To provide information concerning the interaction between groundwater and surface water, staff gages were installed at 10 locations in the major surface water bodies in the site vicinity. Site locations included several locations along the Blue River, in the fresh water pond, and in the wetland area. The locations of staff gages are shown on Figure 7.

2.6.1.2 Well Nests.

As previously discussed, three additional shallow monitoring wells one intermediate well and three deep monitoring wells were constructed during Phase II. The three deep well and one intermediate well locations were selected adjacent to shallow wells in order to provide vertical hydraulic gradient data.

2.6.1.3 Piezometers.

As discussed previously, the water levels in the upper aquifer monitoring wells, which were installed in Phase I, indicated that the freshwater pond caused a mound in the water table. To evaluate the relationship between the the pond and upper aquifer, four piezometers were installed, one on each side of the freshwater pond.

2.6.2 Slug Tests.

Permeability tests were conducted in the upper aquifer by conducting slug tests at 10 Phase I monitoring wells. The first step in the procedure after each well had been developed was to measure and record the static water level. Then the well being tested was instrumented with a pressure transducer, calibrated to read out water level changes in feet. It was connected to an electronic data logger. After activating the data logger, a volume of water was displaced by quickly lowering a solid slug into the well.

Water level in the well was measured by the pressure transducer, and recorded in minutes by logarithmically increasing the time steps on the data logger. The first 10 time steps were at the following elapsed time: 0, 0.003, 0.007, 0.01, 0.013, 0.017, 0.020, 0.233, 0.026, 0.03. All of the wells tested recovered within a few seconds, indicating high hydraulic conductivity values. Permeability values were calculated using the Bouwer and Rice (1976) method for a partially penetrating well in a water table aquifer.

2.6.3 Pumping Test.

A limited pumping test was conducted at the site in 1984 for the Risk Assessment (Beranek, 1984). Columbia City Well #7 was pumped for 6 hours and water levels were observed in 3 wells on the WRR Site screened in the lower aquifer. The results of this earlier test indicated that pumping the Columbia City well (1) significantly changed groundwater levels in the lower aquifer, and (2) caused lowering of water levels in some of the monitoring wells screened in the upper aquifer.

A passive pumping test was conducted during Phase II of the RI investigation for three purposes: to provide information concerning the hydraulic properties of the lower aquifer, to provide information concerning the hydraulic connections between the upper and lower aquifers, and to document the effects that pumping of the city wells have on groundwater levels at the WRR Site. City Well #8 has a higher pumping rate and is located closer to the WRR Site than Well #7. Consequently, it exerts a potentially greater influence on the hydrogeologic system and was therefore selected as the well for conducting the passive pumping test.

The wells monitored during the pumping test are shown on Figure 11. The pumping schedule, water levels in several monitoring wells, and the barometric pressure were recorded during the week of August 22-26, 1988, and the results, for four wells screened in the lower aquifer at the WRR Site are plotted on Figure 12. Four lower aquifer wells on the WRR Site were used as observation wells during the pumping test (Figure 11). The observation wells are located between 700 and 1300 feet from Well #8; drawdowns observed during the pumping test ranged between 3 and 5 feet.

The pumping test was conducted by over-riding the automatic pump start-up system and scheduling 8 hours of continuous pumping followed by 12 hours of recovery from 1:15 pm August 24 to 9:15 am August 25. The pumping test provided water levels representative of aquifer conditions during pumping and after recovery and it provided information which could be used to calculate

the hydraulic properties of the lower aquifer. Water levels were also measured in most of the shallow monitoring wells on the site, and in the surface water bodies during the drawdown and recovery phases. Changes in the water levels at some of these points were used to assess the hydraulic connection between the lower and upper aquifers and between the upper aquifer and surface water.

3.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

The previous section described the specific tasks which were completed during each of the phases of the investigation. The remainder of this section presents a synthesis of the natural system, including the surface features, topography, hydrology, geology, and hydrogeology.

3.1 Surface Features and Topography.

The areas surrounding the WRR Site are a mix of residential, commercial, and agricultural land. A lumber yard with saw mill (Holmes & Co.) is located along most of the northern border of the site and about six acres of this property is included as part of the WRR Site. The closed Columbia City Landfill makes up the northeastern part of the site. The Blue River flows south along the eastern border and curves to the west to also form the southern border of the site. The municipal cemetery and a small residential development lie along the western and northern boundary. East, across the Blue River, is a small industrial park. The property across the river to the south is used for agriculture.

The linear nature of Blue River, with its 90-degree bend at the southeast corner of the site, suggests that the river has been channelized into its present configuration. Steep banks lead down to the water surface, which is 10 to 15 feet below the generally flat ground surface on either side of the river. Prior to channelization, the river would have followed a more meandering pattern across this flat area, the flood plain. The sludge ravine may have been part of a previous, natural river channel. The site's natural topography can be separated into two distinct areas, the floodplain and an upland area. This division is delineated on the topographic map (Figure 2) as an Indian Treaty Boundary Line. The line also demarks the current Columbia City limits.

Significant man-made topographic features include the landfill, numerous excavations on the site, and the previously mentioned channelized Blue River. The landfill at the northeast corner of the site measures 500 feet north to the south and several hundred feet wide from west to east. The east side rises steeply away from the river to a height of about 35 ft above river surface level. On the south it rises equally steeply, 25 ft above the flood plain surface. The top of the landfill is littered with rusting appliance

carcasses, the side slopes are vegetated with scrub trees which appear to be 20 to 30 years old.

The major surface features are marked on an aerial photograph (Figure 3). Three major excavations at the site are the "fresh water pond", the "sludge ravine" area and the "discolored area". The pond extends about 250 ft north to south and about 100 ft east to west. As the name suggests, the "sludge ravine" was originally a ravine which was filled in with waste. Prior to channelization, it may have been part of the natural course of the Blue River. Waste which had been disposed of in the ravine and surrounding discolored soil was excavated from the area in 1986 pursuant to the EPA Administrative Order on Consent. The excavation extends about 10 ft below ground surface (to the water table) and is about 200 ft long west to east. It is about 60 ft wide at the west end, decreasing in width to a point at the eastern end. The "discolored area" was excavated in 1988 as a part of an Administrative Order issued by EPA in February 1988. The "discolored area" is "L" shaped and is 100 feet long at its base, 100 feet high, 50 feet wide and about six feet deep.

Several other small depressions were apparently excavated by the operators of WRR. The two most evident excavations are the "tar pit" and the "oil decanting pit". In 1986, visibly contaminated soil in these areas was excavated and disposed of off site pursuant to the EPA Administrative Order of Consent. The tar pit is a circular excavation about 15 ft across; the oil decanting pond is angular, about 50 ft in diameter.

The ground elevation above mean sea level (amsl) ranges from about 812 ft in the channel of the Blue River, to 825 ft on the flood plain area, to 840 ft on the uplands on the site. The elevation of most of Columbia City is about 850 ft and the elevation of the top of the landfill is about 850 ft.

A water tower is located just across the river to the southeast of the site. The city well field is located north of the landfill. A U-shaped primary water main loops to the west from the well field, through Columbia City, then south and then back east to connect with the water tower.

3.2 Regional Geology.

The Columbia City area was repeatedly glaciated during the Quaternary Epoch and the bedrock is overlain by approximately 200 ft of unconsolidated glacial material. Precambrian basement rocks are located beneath about 3,000 ft of relatively flat-lying sedimentary rocks. A generalized regional geologic cross section is presented in Figure 13.

3.2.1 Surficial Geology.

The surficial geology in the Columbia City vicinity is the result of the most recent glaciation (Wisconsinan). Areas are located north and west of the City which show a mixture of both ground and end moraines. South and southwest of the City, occasional deposits of sand and gravel outwash are observed along the Eel River. The moraines, considered to be part of the Lagro Formation (Wayne, 1963) are typically 200 to 300 ft thick, consisting mostly of a clayey till with little sand. Between several of the end moraines, deposits of outwash material are found. These appear to be members of the Atherton Formation. The sediments of the Atherton Formation consist of gravel, sand, silt and clay; they resulted from glacial activity, but were deposited extraglacially as outwash valley trains (Wayne, 1963).

The published geologic literature has little detailed information about the glacial deposits or stratigraphic sequences in northeastern Indiana. The Columbia City area is located in a zone where two separate lobes from the Wisconsinan glaciation collided or overlapped. One lobe travelled down the Lake Michigan trough, and the other flowed out from Lake Erie. The regional glacial geologic map of the Fort Wayne area (Johnson and Keller, 1972) indicates there are significant areas of glacial outwash along the Eel River and also at locations along the Blue River. Outwash deposits appear to outcrop at the surface along the west bank of the Blue River for several miles north of Columbia City, directly north of the WRR site along the Blue River.

A regional geologic map (Burger, et al, 1966) indicates the bedrock surface is at an elevation of approximately 600 ft amsl beneath Columbia City. Therefore, the total thickness of unconsolidated glacial materials is in the range of 200 to 250 ft. Well logs were obtained from the Indiana Department of Natural Resources (DNR) for water supply wells in the Columbia City Vicinity. Those which extend deep enough confirm that bedrock is located approximately 200 ft below ground surface.

3.2.2 Bedrock Geology.

The bedrock beneath Columbia City is Devonian-aged limestone and dolomite of the Traverse and Detroit River Formations. The bedrock surface dips gently to the northwest. A dendritic drainage pattern appears to be expressed on the bedrock surface beneath northeastern Indiana. This pattern probably indicates a period of exposure and weathering prior to glaciation. A branch of the buried bedrock valley, oriented from east-northeast to west-southwest, is located just to the south of the site. Total relief of the bedrock surface is probably less than 50 ft locally.

The Traverse and Detroit River Formations are typically dense, cherty limestones and dolomites (Shaver, et al, 1986). The Wabash Formation, which comprises the bedrock surface in the bedrock valley just to the south of Columbia City, is also cherty limestone and dolomite.

3.3 Surface Water Hydrology.

Major regional drainage patterns are oriented from northeast to southwest along the axis of the glacial moraines which were formed by the Wisconsin glaciers. The Blue River, which bounds the WRR site on the east and south, follows this general trend, as does the Eel River, which the Blue River flows into about 2.5 miles south of Columbia City.

The Blue River flows from northeast of Columbia City, past the WRR site on both the east and south boundary. After passing the site, the river turns again southward where, after a couple of miles, it flows into the Eel River. Water levels in the Blue River adjacent to the WRR site measured in October 1988 indicate that the river gradient is approximately 0.002 ft/ft.

There are scattered small lakes around Columbia City; some are apparent on the U.S.G.S topographic map, although only one is located within the area covered by Figure 2. Some appear to be natural, others apparently are the result of past gravel mining operations. The water levels in the lakes are generally expressions of the local water table.

3.4 Regional Hydrogeology.

Columbia City is located on the outwash zone between two morainal areas, and therefore, the unconsolidated glacial deposits in the Columbia City area contain extensive deposits of sand and gravel. These are generally productive aquifers and so there has generally been no need to develop water supplies from the underlying bedrock. The aquifers of significance to this investigation are two sand and gravel aquifers within the upper 200 ft of the glacial deposits.

The Indiana Department of Natural Resources (DNR), Water Resources Division reported records of 55 wells within approximately two miles of the WRR Site. Locations for the wells are plotted on Figure 10. The well logs are included in Appendix D. Pertinent information regarding each well has been summarized in a table included at the beginning of the Appendix.

The three Columbia City municipal wells are among those listed. The Columbia City well field is located just north of the WRR Site along the Blue River. Of the three wells, two (#7 and #8) are used alternately by the City utilities to keep the two city water towers (reservoirs) filled. Use of well #6 has recently been discontinued because a leak had developed in its casing and sand had been drawn into the pump. Well #8 pumps at approximately 1500 gpm and is located within 100 ft of the site. Its location is shown on many of the site maps (including Figures 7 and 10). Well #7, with a pumping capacity of about 1200 gpm, is located about 600 ft northeast of well #8. City pumping records indicate that the pumps are active approximately 8 to 10 hours per day.

3.5 Hydrogeology in the Vicinity of the WRR Site.

To accomplish the objectives of the RI, soil borings were made, monitoring wells were completed, water levels were measured in ground-water and surface water, a pumping test was conducted, and numerous soil, sediment, surface water and groundwater samples were collected. Section 2.0 of this report describes in detail, the procedures and techniques which were followed in each sub-task of the investigation. The sections which follow present an analysis of the natural hydrologic and hydrogeology system on the basis of the data compiled for this investigation and previous studies.

3.5.1 Site Hydrostratigraphy.

The three Phase II lower aquifer monitoring wells (MW-1D, MW-8D and MW-13D) were drilled to a depth of about 150 ft below ground surface and the logs for these wells provide a major part of the stratigraphic information for the site. None of the borings was extended to bedrock, however, the boring log for Columbia City Well #8 indicates that bedrock is located at about elevation 646 ft (amsl), or about 190 ft below ground surface.

Four hydrostratigraphic units can be defined in the unconsolidated material above bedrock at the WRR Site.

- o The vadose zone extends from ground surface to the water table and varies in thickness from a few feet to 25 or 30 ft, depending on surface topography.
- o The upper aquifer ranges in thickness between 5 and 30 ft, depending on the water table elevation and the presence or absence of confining layers.
- o An aquitard or confining layer is found between the upper aquifer and the lower aquifer and appears to be between 20 to 40 ft thick.
- o The lower aquifer extends from the confining layer down to the bedrock surface, at approximate elevation 646 ft (amsl), and appears to be up to 100 ft thick.

3.5.1.1 Geologic Cross Sections.

Figure 14 is a base map for the site showing the locations of five geologic cross sections. Cross sections A-A', B-B' and C-C' transect the site from west to east; cross sections D-D' and E-E' transect the site from north to south.

A sandy upper aquifer was encountered in all borings across the site. It appears to be unconfined at 11 of the 18 shallow wells and piezometers constructed during the RI, and it appears to be confined at five of the shallow wells. At two monitoring well locations (MW-5S and MW-7S), it would appear to vary seasonally between confined and unconfined conditions. Most of the confined conditions occur in the southeast area, perhaps a result of flood plain deposition from the Blue River.

Where the aquifer is confined, the saturated thickness is simply the thickness of coarser grained materials, (sands or sand and gravel) between two confining layers. Where water table conditions exist, the saturated thickness lies

between the confining layer on the bottom and the water table. Because the water table elevations varies through the year, the aquifer thickness varies in the areas in which the aquifer is unconfined.

The base of the upper aquifer is defined by the upper surface of the confining layer. Three borings were made through the confining layer for this investigation, for construction of monitoring wells MW-1D, MW-8D, and MW-13D. In addition, boring logs were obtained for several of the deep wells previously constructed in the site vicinity (PH well, Columbia City well #8, and the "83" series wells (Logs have been obtained for these wells and are included in Appendix C-2).

On the basis of the boring logs for these wells, the base of the upper aquifer is generally found between 790 and 800 ft. Therefore, the thickness of the upper aquifer varies in thickness up to about 30 ft. The base of the confining layer is generally found at elevation 765 to 772. On the basis of the limited number of borings through to the lower aquifer, it appears the confining layer is thickest in the south and thins to the north. Cross section C-C' indicates it is about 40 ft thick along the southern border of the site; Cross section A-A indicates that is about 20 ft thick along the northern border.

None of the borings for this investigation were extended through the lower aquifer to the bedrock. But boring logs for water supply wells in the vicinity indicate that the bedrock (bottom of the lower aquifer) is located at about 650 ft. The three deep monitoring wells for this investigation were installed at approximate elevation 700 ft. Therefore, the lower aquifer is probably between 50 and 100 ft thick. Water supply well logs also indicate the geologic formation grades from coarse sand and gravel just above the bedrock, to silty sand near the top of the aquifer.

3.5.1.2 Soils Laboratory Results.

Information about the physical properties of each of the hydrogeologic units was obtained by submitting 12 soil samples to the Warzyn soils laboratory for Atterburg limits tests and grain-size analysis. Two samples were selected to represent the vadose zone, three samples were selected to represent each of the aquifers, and four samples were selected to represent the confining layer between the aquifers. Results of the physical property tests are summarized in Table 3. Completed laboratory test sheets are included in Appendix E. Laboratory permeability tests were not conducted because the results would have been less representative than the in-situ tests (bail tests and the pumping test) which were conducted.



Both samples selected to represent the vadose zone indicate the surficial soils are fine grained. The sample from the upland area had a greater percentage of fines (silt and clay), while the sample from the southeast area, in the flood plain, had a higher percentage of sand. Both samples were tested for Atterburg limits, indicating generally cohesive soils.

Samples tested for the upper aquifer indicate it is primarily a sand aquifer with few fines and less than 20 percent gravel. Atterburg limits tests were not possible on the samples. Grain-size analysis indicated the confining layer is primarily clayey and sandy silt. The sample tested from the deeper aquifer, at monitoring well MW-13D, was mostly silt with only very little coarse material (sand) and about 20 percent clay.

Samples submitted to represent the lower aquifer also indicate a primarily sand aquifer with some fines (15 to 25%) and some gravel. However, the samples were collected from the upper part of the aquifer and therefore they may not have been representative of the whole aquifer. Records indicate water supply wells in the WRR Site vicinity that are completed in the lower aquifer, are often completed deeper than 150 ft. Also, in general terms, fluvially deposited aquifers, as the lower aquifer appears to be at this location, often show grain size is coarser with depth. Both these reasons suggest the lower aquifer grades to a sand and gravel aquifer nearer to the bedrock contact.

3.5.2 Upper Aquifer Characterization.

3.5.2.1 Monitoring System.

A total of 14 monitoring wells were constructed in the upper aquifer during the two phases of investigation. Monitoring well MW-5S was constructed to act as an upgradient well; monitoring well MW-6S was placed in the municipal landfill; monitoring wells MW-14S, MW-9S, MW-13S, MW-11S and MW-12S were placed along the Blue River; monitoring well MW-2S was placed near the sludge ravine; monitoring wells MW-7S, MW-4S, MW-8S and MW-1S were constructed in the interior of the site; and MW-3S, MW-10S and MW-11S were placed in the southeast area. In addition, the fresh water pond was surrounded by four non-sampling piezometers. Upper aquifer wells and piezometers were screened to intersect the water table. The boring logs for each well are compiled in Appendix C-1. The Appendix is prefaced with a table which summarizes the well construction details.

3.5.2.2 Groundwater Flow in the Upper Aquifer.

Water levels were collected at the WRR Site at 11 times between May and August 1988. Results are summarized in Table 4. Water table/potentiometric maps have been constructed for May 3, 1988 data (Figure 20) and for the water levels after recovery of the pumping test in August (Figure 21). The relatively evenly spaced potentiometric contours along the northern part of both maps indicates the groundwater flow direction is generally from west to east in the upper aquifer. Staff gages at several locations in the Blue River show the river water elevation is consistently 1/2 to 1 ft lower than the groundwater elevations in the monitoring wells in the upper aquifer adjacent to the river. The resulting pattern, as mapped on both upper aquifer potentiometric maps, shows steep hydraulic gradients adjacent to the river, indicating the upper aquifer discharges to the river. Three factors could account for the steeper contour line spacing: (1) aquifer permeability may decrease, (2) aquifer transmissivity may decrease, because perhaps the aquifer gets thinner to the south (see cross section D-D, Figure 18) and (3) there may be poor hydraulic connection between the upper aquifer and the river.

The staff gage in the fresh water pond indicated water elevations which were higher than the surrounding groundwater during the spring (Figure 20). The higher pond level is shown by the concentric potentiometric contour lines surrounding the pond. This indicates radial groundwater flow out of the pond, which locally reverses the gradient to the west of the pond. Later, during the drier part of the year (Figure 21), groundwater levels were higher to the west of the pond and lower to the east, indicating groundwater flow-through conditions. The pond still skews groundwater flow patterns locally at its northern end in the August map. Because of the unusual drought conditions during the summer of 1988, this map is probably a good representation of low flow conditions.

Water elevations in individual monitoring wells varied by two to three ft between May and August, but the direction of groundwater flow was significantly changed only around the freshwater pond. Horizontal gradients have been calculated for three zones across the site for both May and August conditions (Table 5). The gradient between monitoring wells MW-5S and MW-6S represents the average gradient from west to east in the upper aquifer, unaffected by the seasonal recharge from freshwater pond, or by discharge to the river. The gradient was 0.0015 (ft/ft or unitless) in May and 0.0007 in August, indicating a 50 percent decrease between spring recharge and low flow conditions.

Hydraulic gradient on the east side of the pond is represented by the differences in water level between monitoring wells MW-10S and MW-11S. It shows a four-fold decrease in gradient from 0.0051 in May to 0.0012 in August. The gradient is least changed by seasonal differences on the west side of the pond, where the gradient between monitoring wells MW-5S and MW-8S was 0.0010 in May and 0.00085 in August, a decrease of about 15 percent.

Water levels declined in upper aquifer monitoring wells during the pumping test. Total changes ranged from 0.02 ft at monitoring well MW-12S to 0.68 ft at well MW-11S, but these changes did not significantly change the direction of the horizontal hydraulic gradients in the upper aquifer across the site.

A staff gage was placed in the wetland along the north boundary of the site to provide surface water elevation in the wetland (location was about 50 feet north of MW-7S). When compared to the water level in the nearby monitoring wells (MW-4S and MW-7S) it was found that the wetland water elevation is approximately 20 ft higher than the water table. Therefore, it can be assumed that there is little hydraulic connection between the wetland the upper aquifer.

Water levels measured during the pumping test of City Well #8 indicated a downward gradient from the upper aquifer where water levels were measured, so it is possible the upper aquifer also discharges areally through the confining layer to the lower aquifer.

The probable source of major recharge for the upper aquifer is through the infiltration of precipitation. Diffuse areal recharge is probably common across the whole area. Water levels in the upper aquifer at the northwest part of the site were the highest recorded at all measurement times. The excavated area near the cemetery in the northwest part of the site may be an infiltration area, and it may cause a mounding of groundwater in this area.

3.5.2.3 Hydraulic Properties of the Upper Aquifer.

Slug tests were conducted at 10 upper aquifer monitoring wells during Phase I of the investigation. Field procedures used to conduct the slug tests are described in Appendix A and raw data and calculations are included as Appendix G. Permeability values, summarized on Table 6, range from 1.0×10^{-2} cm/sec (29 ft/day) at monitoring well MW-6S, to 3.7×10^{-1} cm/sec (1,040 ft/day) at MW-9S. The average value for the 10 upper aquifer wells is 6.0×10^{-2} cm/sec (170 ft/day).

Values of storativity/specific yield cannot be derived from slug test data collected and analyzed by these methods. However, the porosity of a coarse sand and gravel aquifer is normally in the range of 25% (Freeze and Cherry, 1979). Where the aquifer is unconfined, the specific yield can be estimated as the same order of magnitude as the porosity (0.25).

3.5.2.4 Groundwater Seepage Velocity.

Estimates of the groundwater seepage rate in the upper aquifer can be calculated with the following equation (Freeze and Cherry, 1979), using the values for permeability (K), the hydraulic gradient (i) and the effective porosity (n).

$$V_s = \frac{K i}{n}$$

where: V_s = Seepage Velocity
K = Permeability
i = Hydraulic Gradient
n = Effective Porosity

Although the hydraulic gradients across the site vary annually (because of recharge differences) and vary spatially (because of local controls including the pond and the river), a value of 0.0015 represents a reasonable average horizontal gradient.

On the basis of the average permeability value of 6.0×10^{-2} cm/sec (170 ft/day), the hydraulic gradient of 0.0015, and an effective porosity of 0.25, it can be calculated that the average groundwater seepage rate in the upper aquifer is on the order of 1.0 ft/day or 365 ft per year. Seepage rates could vary annually and locally because of variations in gradient and permeability. On the basis of the lowest horizontal gradient measured at the site (0.0007), and the lowest permeability value (29 ft/day), the lowest probable groundwater seepage rate would be on the order of 30 ft/year. On the basis of the highest horizontal gradient measured within the upper aquifer (0.0051), and the highest permeability value (1043 ft/day), the highest local groundwater seepage rate could be on the order of 8000 ft/year (although it would occur only locally in small, isolated areas).

Significantly steeper hydraulic gradients have been plotted along the east and south site boundaries adjacent to the Blue River. These result from the assumption that groundwater is discharging to the river and they indicate that the permeability of the zone between the upper aquifer and the river bed has a much lower value than the value within the aquifer itself. Because these permeability values have not been directly determined, a groundwater seepage velocity in these areas were not calculated.

3.5.3 Lower Aquifer Characterization.

3.5.3.1 Monitoring System.

The three lower aquifer monitoring wells constructed in Phase II of the investigation were arranged in a triangular pattern. Each was placed adjacent to a shallower well thus forming well nests at three locations. Monitoring Well MW-1D was located in the area south of the old city landfill (Wells MW-1S and MW-1I completed a three-well well nest). Monitoring well MW-8D was constructed in approximately the center of the site, about 400 ft southwest of MW-1D. Nearby, MW-8S forms a two-well nest at this location. Monitoring well MW-13D was constructed near the Blue River at the south border of the site near the east side (adjacent to MW-13S). Monitoring well MW-9S is located within 75 ft of PH well; together, they were also considered a well nest for this investigation.

3.5.3.2 Groundwater Flow in Lower Aquifer.

Water level monitoring during the field investigation week of August 22 - 26 (Monday through Friday) indicated pumping from the city wells located north of the WRR Site does significantly affect the potentiometric surface and hydraulic gradients within the lower aquifer. During the pumping test from 1 pm August 24 to 9 am August 25, groundwater levels were measured at on-site wells every two to three hours by the field investigation team. In addition, 13 of the wells were instrumented with pressure transducers connected to electronic data loggers.

As has been explained, water levels in upper and lower aquifer monitoring wells showed decreases during the pumping phase. While the water level changes in the upper aquifer did not affect gradients and flow direction to a significant degree, extended pumping did reverse the gradients in the lower aquifer. A plot of the pumping activities during the week of the pumping test (Figure 12) shows that the pump was active several times each day, usually for periods of 4 to 6 hours. City utilities personnel explained that the pump is automatically switched on and off by water level sensors in the reservoirs.

Water levels were recorded in monitoring well MW-1D starting on Monday and continuing through Friday, and, in MW-8D, MW-13D and well PH, from Tuesday to Friday. Water levels were never static (Figure 12) but were either falling during pumping or rising during recovery. Water levels were collected at the end of the 8 hour pumping test and after the 12-hour recovery following the test. These levels represented extremes in the water levels or end-points in

the continuum between extended pumping and maximum recovery. The water elevations at surface and ground water monitoring points for these end-points are listed on Table 7. Total change in water level between lowest drawdown at the end of the test and after recovery has also been calculated.

The potentiometric surface was plotted for the water levels measured in the lower aquifer at the end of the eight hour pumping test (Figure 22). It shows that the gradient is directly toward the pumped well at the north side of the site. The hydraulic gradient, calculated between monitoring wells MW-13D and MW-1D, was 0.0011 (0.71 ft/650 ft).

A potentiometric surface was also plotted for the water levels representing the aquifer condition after 12 hours of recovery (Figure 23). It indicates that, in the absence of pumping, there is a regional gradient beneath the WRR Site trending from the northwest to the southeast. The hydraulic gradient calculated between monitoring wells MW-8D and MW-13D was 0.0015 (1.01 ft/680 ft).

3.5.3.3 Hydraulic Properties of the Lower Aquifer.

The normal pumping schedule of Columbia City Well #8 was modified to conduct a pumping test to calculate hydraulic properties of the lower aquifer. The duration of the pumping test was dictated by reservoir capacity and water usage in Columbia City. The two city water reservoirs were allowed to nearly empty before the test was started, and then they were filled to nearly overflowing for the drawdown phase. The timing was selected so that pumping would occur during the daytime when water use would be highest, and recovery would take place when water use was lowest (during the night). This allowed for the longest possible pumping period and the longest possible recovery period.

The pump started automatically at 7 am on Wednesday before City employees arrived at work. But it was shut down within about an hour to allow drainage of the reservoirs, and re-recovery of the aquifer. The pump was started at 1:15 pm on Wednesday and run continuously until 9:15 pm. Several changes are evident in the drawdown curves (Figure 12) during the first half hour of the test, because City crews were attempting to stabilize the pumping rate close to 1500 gpm (200 cfm). The total volume of water pumped was 746,000 gallons, yielding an average pumping rate of 1554 gpm (208 cfm) during the 8-hour test. The pump was not re-started until 9:30 am the next morning, allowing 12 hours of uninterrupted recovery.

Among the numerous methods available for analyzing pumping test data, two methods, the Jacob straight-line method (Kruseman and deRidder, 1970) and the Log-log curve match leaky aquifer (Log-log method) method (Lohman, 1972) were selected as potentially consistent with the hydrogeologic conditions on the site and providing reasonable models for the observed responses. The raw data, plots of data curves, and calculations are included in Appendices H-1, H-2, and H-3, respectively.

Both pumping test analysis methods yield transmissivity (T) and storativity (S) values. Permeability (K) can be estimated as the transmissivity divided by the aquifer thickness. On the basis of the boring logs and derivative cross sections, the aquifer was assumed to be 100 ft thick. The values calculated by both methods are summarized for each observation well in Table 8. Average values are calculated for both analysis methods and the transmissivity/permeability values agree within about 30 percent.

Calculated storativity values differed by two orders of magnitude. The probable reason for the discrepancy is evident when the assumptions implicit in each analysis method are evaluated. The Jacob method assumes (among other things) the aquifer being pumped is homogeneous and isotropic, of infinite areal extent, and confined, with no recharge to the aquifer. The Log-log method is based on the same equation, but allows for leakage into the aquifer from an overlying or underlying confining layer. Therefore, the discrepancy between the storativity values calculated by the two methods is attributed to this leakage factor.

Observations at the upper aquifer wells during the pumping test indicate water levels in the upper aquifer declined at measured locations (Table 7), suggesting there is leakage from the upper aquifer to the lower aquifer. Given the same transmissivity value, both leakage from the aquifer above and a higher storativity value would result in less drawdown at a given observation well. Therefore, it is likely the Log-log method gives storativity and transmissivity values which are more representative of lower aquifer conditions at the site. The high storativity value calculated from the Jacob method is attributed to recharge through the confining layer.

The Log-log method is based on the concept that leakage into a confined aquifer during a pumping test causes the observed drawdown at a well to deviate from the ideal Theis curve during the later part of a pumping test, when leakage provides recharge. The Log-log curve for an aquifer with no leakage is identical to a Theis Curve, and for the early part of a pumping

test, the curves for each observation well follow the steep part of the Theis curve. However, later in the pumping test, the curves flatten out, plotting lower than the Theis curve, because leakage effects diminish further drawdown.

The transmissivity, storativity and leakance values calculated by the Log-log method are summarized in Table 8. The average permeability of the lower aquifer was calculated to be 4.8×10^{-2} cm/sec (140 ft/day), the average storativity was calculated to be 3.6×10^{-4} (unitless), and the average vertical permeability (K) was calculated to be 0.05 ft/day.

The log-log time-drawdown curves for each of the observation wells (MW-1D, MW-8D, MW-13D and PH well) used during the pumping test (Appendix H-2) were found to match the " $v^2/u=0.2$ " Log-log curve best. However, because the pumping test was relatively short in duration, the flattening of the curve only extends a short distance. If it had been possible to conduct the pumping test for a longer period of time (e.g., 24 or 48 hours), there would probably have been a longer flattened section of the curve, and it might have been possible to obtain a more accurate leakage factor. Permeability and storativity values have been rounded to two significant figures, but the leakance factor had to be rounded to one significant figure.

An analytical model based on the Theis equation (Walton, 1985) was used to further evaluate the pumping test results. The pumping rate and duration was simulated in a model using the transmissivity/storativity combinations derived by both methods (A print out of the Fortran code is included in Appendix I). The model is limited to the assumptions of the Theis equation enumerated above for the Jacob Method. The modeling indicated the lower storativity value (3.6×10^{-4}) was more consistent with the observed cone of depression which formed during the pumping test. The simulation of the pumping test with the higher storativity value (2.5×10^{-2}) yielded drawdowns which were only a fraction of the drawdowns actually observed during the pumping tests, and which did not reverse the gradient across the site (as was observed during the pumping test).

To further evaluate the pumping test data, a computer program was used that superimposes the Theis equation drawdown on a regional gradient. The program (model) was used to simulated two scenarios, using the average transmissivity and storativity values calculated by the Log-log curve match analysis. The first scenario was to model the lower aquifer conditions without pumping, (simulating after recovery conditions). Figure 29 shows the result, a regional gradient toward the southeast, onto which the change due to pumping

will be superimposed. For the first scenario, an 8-hour pumping test was super-imposed on the regional gradient (Figure 30). It shows at least two significant differences from the plot of water levels observed in the lower aquifer at the end of the pumping test (Figure 22): 1) water levels are generally lower (drawdowns are greater) at the four observation wells and 2) the potentiometric contour lines show a different orientation.

The generally lower simulated water levels can be anticipated, because the model does not account for the leakage from the upper aquifer. However, the simulated potentiometric surface during pumping (Figure 30) is oriented much more radially around the pumped well, and suggests a generally west to east gradient in the lower aquifer beneath most of the site. The observed potentiometric surface (Figure 22) indicates the actual gradient is oriented more toward the north during pumping. This difference results from observed levels at monitoring well MW-8D and the PH well, which show a greater drawdown than does the simulation. A possible explanation is that the calculated storativity was lower at these wells.

A second basic analytical model was used to derive an approximation of the leakage volume from the upper to lower aquifer during the pumping test. The method uses the Hantush-Jacob equation (1955), which was incorporated into a model format by Walton (1985). The model calculates a drawdown for a well at a specified distance from the pumped well on the basis of the aquifer transmissivity and storativity, the vertical permeability of the confining layer, and the pumping rate and duration. The model was used iteratively for each observation well location, varying values for the vertical permeability (K) of the confining layer, until the simulated drawdown matched the observed drawdown. The model input variables and resulting vertical permeability values are summarized in Table 9. A listing of the model, and input and output values are included in Appendix I-3.

A number of assumptions were made to calculate vertical permeability by this method and so the modeled results should be considered as rough estimates only. However, the results were in general agreement with the results derived from analysis of the pumping test data.

A second scenario was conducted by superimposing the pumping test on the regional gradient, but also simulating leakage across the site and simulating lower storativity in the western part of the site. Leakage from the upper aquifer was simulated by using low volume injection points in the areas of major drawdown across the WRR Site. The model used does not allow

transmissivity to vary spatially. To test whether decreased transmissivity to the west could be the cause of the greater-than-expected drawdowns, several small volume discharge points were modeled in the vicinity of MW-8D. This procedure is not a standard modeling procedure, but it can give a qualitative indication of the effects of decreased storativity. The result (Figure 31) suggests the observed potentiometric surface in the lower aquifer at the end of the pumping test results from a combination of (1) leakage from the upper aquifer and (2) lower aquifer storativity to the west.

3.5.3.4 Groundwater Seepage Velocity.

Because variations in the pumping cause the hydraulic gradients to oscillate from north to southeast, groundwater flow direction also has the potential to oscillate between the two directions. Average maximum seepage velocities can be calculated for each end member of the gradient extremes using the average lower aquifer permeability value and the maximum gradients for the pumping phase and the recovery phase.

	<u>Horizontal Gradient</u>	<u>Average Permeability</u>	<u>Effective Porosity</u>	<u>Groundwater Seepage Rate</u>
Toward Well	0.0011	140 ft/day 4.8×10^{-2} cm/sec	0.25	0.60 ft/day
Regional Flow to Southeast	0.0015	140 ft/day 4.8×10^{-2} cm/sec	0.25	0.80 ft/day

The regional gradient away from the City well field during recovery is stronger than the local gradient toward the City well during pumping. Furthermore, the City wells are pumped less than 50 percent of the time. In the simplest case, it would appear that contaminants potentially reaching the lower aquifer would in effect, "take three steps toward and four steps away" from the City well field during a day with equal duration of pumping and non-pumping phases.

The potential for contaminants to reach the lower aquifer can be assessed by analyzing the groundwater flow system in three dimensions and evaluating the interaction between the upper and lower aquifers.

3.6 Interaction Between the Upper and Lower Aquifer.

The upper and lower aquifer both consist of coarser grained materials, including sand and sand and gravel. They are separated by a layer of finer grained materials which has been identified as the confining layer. It has been shown the horizontal gradients within the upper aquifer are relatively unaffected by changes in the potentiometric surface in the lower aquifer. Nonetheless, after eight hours of pumping from the lower aquifer, water levels had declined in all monitoring wells screened in the upper aquifer at the site, indicating significant hydraulic interaction between the two aquifers. Water level declines in the upper aquifer during pumping ranged between 0.02 feet at monitoring well MW-12S, and 0.68 feet at MW-11S (maximum water level declines at each well are listed in Table 7 and plotted on Figure 24). These observations support the conclusion from the pumping test data that there is leakage from the upper to the lower aquifer during pumping.

The leakage volume at a given location is proportional to both the magnitude of water level decline and the storativity of the upper aquifer at that location. Rate of rise hydraulic conductivity tests performed in the upper aquifer at the WRR Site do not permit the calculation of storativity values. However, storativity values for confined aquifers are characteristically several orders of magnitude lower than the storativity (or specific yield) for unconfined aquifers (Freeze and Cherry, 1979, pp. 60-61).

The largest water level decline observed in the upper aquifer observation wells during the pumping test was 0.68 feet at monitoring well MW-11S. This drawdown may be readily explained by the presence of confining conditions in the vicinity of this well and does not indicate a higher degree of interconnection between the shallow and deeper aquifers at this point. Both confining conditions and drawdown vary across the site in the upper aquifer (Table 7). Areas of greater drawdown do not indicate that leakage is greater. Rather, it is apparent that the variability observed in water level declines in observation wells within the upper aquifer is primarily a function of the water pressure conditions (i.e., confined or unconfined) within this aquifer.

As within an aquifer, the groundwater flow between aquifers is driven by hydraulic gradients. To evaluate the potentiometric distribution between the aquifers and across the confining layer, a series of cross sectional potentiometric plots were made. To derive an accurate picture of the potentiometric distribution, it is necessary to plot water level information on a cross section which is oriented parallel to the groundwater flow

direction. Section B-B' was selected to represent the upper aquifer, because the hydraulic gradient in the upper aquifer is from west to east. Section E-E' was selected to show gradients in the lower aquifer, because the gradient in the lower aquifer is from northwest to southeast. Two plots were necessary for each section, one to evaluate the post-pumping potentiometric distribution, and the other to evaluate post-recovery conditions.

Section B-B' is oriented from east to west and therefore best represents groundwater flow in the upper aquifer, although it also yields valuable information for the lower aquifer in post-recovery, because the lower aquifer gradient has an easterly component. Figure 25 (Section B-B' with maximum drawdown) shows the essentially horizontal flow in the upper aquifer with a strong downward gradient to the lower aquifer through the confining layer. Figure 26 (Section B-B' with maximum recovery) shows a similar horizontal flow in the upper aquifer, although the gradient is steeper near the Blue River than it was during the maximum drawdown. This implies a higher discharge rate to the river. (River levels were observed to decline 0.01 foot during the pumping test.) Vertical gradients are strongly upward and toward the Blue River (from lower left to upper right in the Figure).

Both Figures 27 and 28 (Section D-D') are oriented perpendicularly to the groundwater flow direction in the upper aquifer; therefore, they do not show the major components of the gradients in the upper aquifer. Figure 27 (Section D-D' with maximum drawdown) shows a vertical downward gradient across the whole site during pumping, which is apparent even in the upper aquifer. It shows a local mounding in the upper aquifer in the southeast section (between MW-10S and MW-3S), and it shows discharge to the Blue River from the upper aquifer. The 0.32 ft decline in water level at MW-1S suggests some significant leakage from the upper aquifer in that vicinity.

Figure 28 (Section D-D' with maximum recovery) shows a strong upward gradient is indicated across the northern two-thirds of the site. The potentiometric distribution suggests there is a divergent flow at some depth below ground surface on the southern third of the site. In general, the potential for flow is upward from the lower aquifer toward the river, which is a discharge area.

As on map view contour plots, groundwater flow paths in the cross sections have the potential to flow from higher numbered potentiometric contour lines to lower number areas. Flow lines are refracted by changes in permeability. In the cross sections for this project, the groundwater flow will tend to be horizontal in the aquifers and vertical through confining layer. It should be noted the cross sections are drawn with a 5 to 1 vertical exaggeration.

The same reversal of gradient between upper and lower zones during pumping and recovery can be analyzed numerically by calculating the vertical gradients at each well nest. The calculations are summarized in Table 10. The downward gradients at the end of 8 hours of pumping are three to four times greater than the maximum upward gradients, which were measured at the end of 12 hours of recovery. The gradients shown are maximum values. As with the horizontal gradients, the field conditions are constantly oscillating between the two extreme values. However, averaged over time, the vertical gradients may tend to favor the downward transport of contaminants present in the upper aquifer.

The necessary values to calculate the leakage rate between the aquifers are: the vertical gradient (i), the vertical permeability (K) and the area across which the leakage occurs. Values of K and i have been estimated, from the pumping test analysis (Table 8) and site observations (Table 10). Entered into the following equation, these values can be used to make a rough estimate of the maximum leakage volumes across the confining layer, driven by the vertical gradients.

$$Q_v = K_v \cdot i \cdot A$$

where: Q_v = Seepage Volume across defined area
 K_v = Vertical Permeability
 of Confining Layer
 i = Vertical Hydraulic Gradient
 A = Area across which seepage occurs

Several factors limit the accuracy of the calculation.

- o Vertical permeability value is valid to only one significant figure.
- o Vertical permeability value is likely to vary across the site.
- o The hydraulic gradients used represent maximum measured values, yet observations indicate the gradients are continually changing between these values.
- o The hydraulic gradients vary spatially, having higher magnitude closer to the pumped well, where drawdown is the greatest.

The calculations of vertical seepage rate in the vicinity of each deep well is presented in Table 11. To facilitate comparison, the seepage rates were calculated to represent average leakage across 1-acre area. The downward leakage at maximum drawdown is three to five times greater than the upward leakage volume during full recovery. Therefore, it would appear the potential exists for the migration of contaminants from the upper aquifer to the lower aquifer.

An approximation of maximum potential leakage from the upper to lower aquifer under current conditions can be made from the hydraulic properties determined in this study, and by assuming maximum probable pumping rates under the present circumstances. The total leakage (L) for a given time span is the product of the leakage rate (Q_v), the area over which the leakage occurs (A) and the duration of the leakage (T). The calculation in equation form is as follows:

$$L = Q_v \cdot A \cdot T$$

The average leakage rate (Q_v) has been calculated (Table 11) for the WRR Site as 50 cubic ft per day per acre (cfd/acre). If Columbia City well were to be pumped continuously for 24 hours, the time (T) would be one day. The area (A) of the WRR Site is approximately 30 acres (Twenty-four hours of continuous pumping would probably cause somewhat greater drawdowns in the lower aquifer, resulting in increased vertical gradient values. However, the increase would not be significant considering the single significant figure of precision imposed on the calculation by the Q_v value). With these assumptions, the variable values are:

$$\begin{aligned} Q_v &= 50 \text{ cfd/acre} \\ A &= 30 \text{ acres} \\ T &= 1 \text{ day} \end{aligned}$$

The calculated volume of leakage from the upper to lower aquifer beneath the WRR Site during 24 hours of pumping would be approximately 1500 cubic ft per day which is equal to approximately 8 gallons per minute. Or, of the 1500 gpm produced by Columbia City Well #8, there is the potential that 8 gpm would be derived from the upper aquifer on the WRR Site. However, the hydraulic gradient is toward the city well in the lower aquifer only during pumping; after (and perhaps during) recovery, groundwater flow reverses toward the southeast as shown in Figure 23. Therefore, there is the potential for

contaminants which might leak through the confining layer to be carried to the southeast after recovery. The calculation of potential contaminant loading is complicated because the potential for leakage into the lower aquifer occurs only during pumping, while groundwater flow to the southeast occurs only during recovery. If City well #8 were pumped continuously, there would be maximum potential leakage but its pathway would be toward the well. The pathway to the southeast only exists when the pump is off and recovery has occurred. However, in that condition, the hydraulic gradient is upward so there would be no potential for downward migration and consequent contamination of the lower aquifer.

By generalizing the flow conditions, it is possible to make an approximate calculation of the potential contaminant loading of the groundwater flux to the southeast. Assuming that pumping causes a gradient reversal 50 percent of the time, it can further be assumed that (1) leakage occurs and (2) a pathway to the southeast exists, 50 percent of the time, albeit different times.

Groundwater flow occurs beneath the WRR site in an aquifer zone which is about 2,000 ft wide (from MW-14s to City Well #8, perpendicular to the regional gradient). The lower aquifer is about 100 ft thick beneath the WRR Site, so the flow path beneath the site has a cross sectional area of about 200,000 square ft. Using the following equation, with aquifer properties derived elsewhere in this report, the volume of groundwater flowing through the aquifer beneath the site is estimated to be 220 gallons per minute:

$$Q_h = k \cdot i \cdot A$$

where:

Q_h = Volume of horizontal groundwater flow
in the lower aquifer (volume/time)

k = Hydraulic conductivity in lower aquifer

i = Hydraulic gradient in the lower aquifer

A = Cross sectional area through which
groundwater flows beneath the site.

$$1.0 \text{ cubic ft/day} = 0.0052 \text{ gallon/minute}$$

It has previously been calculated that during pumping the potential leakage from upper to lower aquifer is 8 gallons per minute. Therefore the potential contaminant loading of the lower aquifer from the entire WRR site is on the order of 1:30.



4.0 NATURE AND EXTENT OF CONTAMINATION

This chapter provides a description of the chemical character of various media at the WRR Site. Chapter 5 provides an analysis of potential contaminant fate and transport.

Below is a summary of the sampling events considered in the evaluation of media contamination:

- o Soil/Waste - Split spoon subsurface samples collected in February, 1988 (Appendix J-6) and July-August, 1988 (Appendix J-7) during drilling operations, and surface soil samples collected in March, 1988 (Appendix J-8).
- o Groundwater - Samples collected in March, 1988 and August-September, 1988, from on-site monitoring wells (Appendix J-3 and J-4) and private and municipal water supply wells in September, 1988 (Appendix J-5).
- o Surface Water - Samples collected in March, 1988 from on-site ponds and the Blue River (Appendix J-2).
- o Sediments - Samples collected in March, 1988 from the same locations and concurrent with surface water sampling (Appendix J-1).

Table 12 is a summary of field sampling activities, number of samples collected and collection dates for Phases I and II.

The following describes the character and distribution of chemical constituents in the media evaluated. The interconnections of media, and the transfer of contaminants from one medium to another are also evaluated.

Compounds have been grouped together, where applicable, to assist in evaluating contaminant migration. For instance, some of the organic compounds detected are probable degradation products. Other organic compounds have been grouped based on their similar chemical characteristics and behavior in the environment. In addition, there are certain organic compounds associated with degradation sequences (i.e., the formation of breakdown products from the parent compound) which have been grouped separately, such as the chlorinated ethanes and ethenes. Specific groupings are discussed below:

- o Total Chlorinated Ethenes - Chlorinated ethenes including tetrachloroethene (PCE), trichloroethene (TCE), total 1,2-dichloroethene (DCE) and vinyl chloride. These compounds represent a potential degradation sequence.
- o Total Chlorinated Ethanes - Chlorinated ethanes including 1,1,2,2- tetrachloroethane, 1,1,2-trichloroethane, 1,1,1-trichloroethane, 1,2- dichloroethane and chloroethane. These compounds represent potential degradation sequences.
- o Toluene
- o Phthalates
- o Pesticides/PCBs - Organochlorine pesticides and the polychlorinated biphenyls (PCBs).
- o Polycyclic Aromatic Hydrocarbons (PAH) - A group of compounds including naphthalene, pyrene, fluorene.
- o Phenols - A group of chemicals of similar composition including chlorinated, methylated and nitrified phenols. Benzoic Acid and benzyl alcohol are also included with the phenols because they are potential degradation products of phenols.

Table 13 is a listing of specific compounds placed in the above groupings of compounds.

Tentatively identified compounds (TIC) were also detected in a number of samples. For the most part, the TICs were reported in the same samples as the Target Compound List (TCL) volatiles or semi-volatiles. Many of the compounds were tentatively identified as alkanes. Given the uncertainty of identification and quantitation of the TICs, the characterization of contamination and the evaluation of associated risks at the WRR site are better represented based on the TCL data.

The metals data for soils and sediment were evaluated using the expected average concentration and common range of elements in natural soil as described in Chemical Equilibrium in Soils (Lindsay, 1979), and Background Levels of Heavy Metals in Ohio Farm Soils (Logan and Miller, 1983). These references were used to evaluate possible elevated concentrations of specific elements in on-site soils, and are provided as comparison only. Published "common ranges" and background concentrations should not be misconstrued as representing background soil conditions at the WRR Site. Average concentrations in soils for other compounds such as cyanide are not

available. Table 14 shows the frequency of chemical detects for various media at the WRR Site.

The frequency of detection, minimum, and maximum concentrations and geometric means for the TCL parameters in various media are shown in Tables 15 through 27. Since most of the samples represented either uncontaminated or slightly contaminated areas and few samples were from relatively contaminated areas, the data tended to fall into a log normal distribution. The geometric mean of the positive data was selected, as opposed to the arithmetic mean, because it represents the most probable mean value (the central tendency) of a log normal distribution. The geometric mean is the positive "n"th root of the product of n positive numbers:

$$\text{Geometric mean} = \sqrt[n]{(x_1) (x_2) (x_3) \dots (x_n)}$$

The geometric means presented in this report provide a representative mean concentration of a specific chemical within various media at the WRR Site. Instances where the geometric mean is substantially lower than the maximum concentration for a particular chemical, indicate that contamination is localized in one or more areas at the Site.

4.1 Soil/Waste Characterization.

Seventy-four split-spoon soil samples were collected at 26 Phase I soil boring locations. Twenty-two Phase II auger probe borings were drilled to define the lateral extent of visual contamination in the southeast area of the site. Soil from the auger probes was classified visually and screened with a portable photoionization detector. Soil borings to be split-spoon sampled were selected based on the auger probe findings. Forty split-spoon samples were collected at 20 Phase II soil boring locations. Phase I samples were analyzed for the full CLP TCL parameters (volatiles, semi-volatiles, pesticides/PCBs, and metals). The purpose of the Phase II samples was to define the lateral extent of contamination as opposed to the nature of contamination. Therefore, phase II samples were analyzed for TCL volatiles only, except samples from soil borings, SB-17A and SB-18A, conducted during Phase II. The two samples from SB-17A were only analyzed for TCL metals, and the two samples from SB-18A were analyzed for TCL semi-volatiles, in addition to volatiles.

Tables 15 and 16 list the frequency of detection, minimum and maximum concentration and geometric mean for EPA TCL Parameters detected in Phase I and II soil boring samples. The following discussion will chemically differentiate where possible those areas of contaminated soils as opposed to what would be considered "background."

4.1.1 Organic Character - Soil/Waste.

The TCL organics results for the soil/waste samples indicated that volatiles, phthalates, and polycyclic aromatic hydrocarbons (PAH) were the main organic contaminants.

4.1.1.1 Volatiles.

Compounds tended to be scattered at various locations at relatively low concentrations, with the elevated levels occurring in a few localized isolated areas. As shown in Table 15, although the maximum concentrations of some compounds were very high, the geometric means were much lower. For example, the maximum concentration of 1,2-dichloroethene was 71,000 ug/Kg, yet the geometric mean was 169 ug/Kg. Similar situations exist for trichloroethene (43,000 ug/Kg and 73 ug/Kg), toluene (59,000 ug/Kg, and 171 ug/Kg) and others. The chlorinated ethenes represent the highest concentration of volatile organics in the soil boring samples. Chlorinated ethenes were detected in 55 of 113 soil boring samples collected and analyzed during Phases I and II, though most were located in the southeast area of the site. Figure 32 shows soil boring locations and total chlorinated ethene concentration with depth. The figure shows several significant factors:

- o Chlorinated ethene concentration increased with depth at almost all locations, with the highest detected concentrations in the southeast corner of the site at the 10-ft depth in SB-33 (92,700 ug/kg), SB-36 (83,882 ug/kg), and SB-12 (71,000 ug/kg);
- o an isolated source of ethenes exists in the area of SB-7 (94,000 ug/kg) located between the facility building and the Blue River at the southern edge of the Site;
- o The wide scatter in total chlorinated ethene concentrations, even for borings located very close to each other (i.e. SB-36 and SB-24, SB-12 and SB-32) suggests random spillage as opposed to large scale dumping.

Tetrachloroethene, trichloroethene and total 1,2-dichloroethene were detected at approximately the same frequency during Phase I and II; however, total 1,2-dichloroethene was generally at a higher geometric mean concentration.

Vinyl chloride was detected in only one sample (SB-002 at 10 ft) at a concentration of 8 ug/kg.

Chlorinated ethanes were detected in 16 of 113 soil boring samples collected during Phases I and II. As with the chlorinated ethenes, total chlorinated ethanes concentration increased with depth in the boring. The spatial extent and concentrations of the chlorinated ethanes were considerably less than that of the chlorinated ethenes.

With the exception of soil borings SB-5, SB-6 and SB-8 (where total chlorinated ethanes ranged from 4 ug/kg to 57 ug/kg), the occurrence and higher concentrations of chlorinated ethanes centered around SB-36 (10 ft) where the total chlorinated ethane concentration was 9,605 ug/kg. 1,1,1-Trichloroethane and 1,1-dichloroethane were the only chlorinated ethanes detected in soil borings.

Toluene was the most frequently detected (62% of samples) and widely distributed volatile compound detected in the soil boring samples. However, it was usually detected at much lower concentrations than other volatiles. Table 15 shows that although toluene was detected as high as 59,000 ug/kg, the geometric mean of toluene concentration was 171 ug/kg. Figure 33 shows the distribution and concentrations of toluene in the subsurface soils. As with the chlorinated ethenes and ethanes, concentrations of toluene increased with depth in the soil. Away from the southeast area, toluene was generally detected at concentrations less than 200 ug/kg. Maximum concentrations were detected in the southeast corner of the Site (21,000 ug/kg at SB-10 and 59,000 ug/kg at SB-21). Some of the toluene detected in the samples may be the result of laboratory contamination. Benzene, ethylbenzene and total xylenes were also detected in soil boring samples; however, at considerably lower concentrations and less frequently than toluene. Benzene was detected in 2 samples (maximum concentration 4 ug/kg at SB-19), ethylbenzene was detected in 10 samples (maximum concentration 1,200 ug/kg at SB-10) and total xylenes were detected in 10 samples (maximum concentration 4,300 ug/kg in SB-21).

4.1.1.2 Semi-Volatiles.

Phthalates were the semi-volatiles most frequently detected in soil boring samples. Of the 73 Phase I soil boring samples, 30 had detectable amounts of phthalates, though as with volatiles, the geometric mean of phthalate concentrations was in the range of 200 to 400 ug/kg. The contract required quantitation limit (CRQL) for phthalates is 330 ug/kg. Detection of

phthalates near or below the contract required quantitation limits (CRQL), 330 ug/kg, are suspect, as these compounds are typical sampling and laboratory contaminants. Highest total phthalate concentrations were detected in the 10-foot sample from SB-19 (81,000 ug/kg) and in the 6-foot sample from SB-12 (169,000 ug/kg) located in the southeast corner of the site. The most frequently detected compound in the phthalate group was bis(2-ethylhexyl)phthalate (DEHP), detected in 23 samples and di-n-butylphthalate, detected in 11 samples. The phthalate group of compounds were widely distributed over the site, with no apparent correlation to location or depth.

The frequency of detection of polycyclic aromatic hydrocarbons (PAHs) was considerably less than phthalates. As a group, PAHs tended to be infrequently detected at low concentrations across the Site and with the exception of SB-18, SB-18A and SB-12 where PAHs were detected in the 6-ft samples, all detects were confined to the upper 2-ft of soil borings. The PAHs were detected in 8 of 74 Phase I soil boring samples. They were only detected in three samples above one mg/kg and two of those were in the same boring. The highest concentration was located at 2 ft in SB-18 (158,200 ug/kg total PAH). The concentrations of total PAH at SB-18 were approximately 40 times higher than any other soil boring location. Location SB-12, which had the second highest concentrations, had a total PAH concentration of 3,400 ug/kg. A second soil boring at location SB-18 (SB-18A) was conducted during Phase II. Split spoon samples from 5-ft and 10-ft were submitted to the laboratory for semi-volatile analyses to confirm the Phase I results from SB-18. Total PAHs were detected in the 5-ft sample of SB-18A at a concentration of 52,880 ug/kg. No PAH's were detected at 10 feet.

The diversity of PAH constituent compounds detected in SB-18 and SB-18A was greater than in any other soil sample or other sampling medium in which PAHs were detected. Of the 14 PAH constituent compounds detected on-site, 12 were detected in SB-18 and all 14 were detected in SB-18A. SB-18 and SB-18A were also the only locations where PAH constituent compounds were detected that are considered as possible or probable human carcinogens.

Phenol and 2-methylphenol were only detected in one sample; both in the 2-ft sample from SB-8 at 240 ug/kg and 210 ug/kg, respectively.

4.1.1.3 Pesticides/PCBs.

PCBs were only detected in soil boring samples from three locations:

<u>Boring</u>	<u>Depth (ft)</u>	<u>Aroclor</u>	<u>Concentration (ug/kg)</u>
SB-12	2	1260	1400
SB-19	10	1248	230
SB-20	2	1254	640

Pesticides were also only detected in soil boring samples at very low concentrations:

<u>Boring</u>	<u>Depth (ft)</u>	<u>Pesticide</u>	<u>Concentration (ug/kg)</u>
SB-19	10	4,4'-DDE	27
SB-19	10	4,4'-DDD	57
SB-20	2	4,4'-DDE	100
SB-24	2	Endrin	19

4.1.2 Inorganic Character - Soil/Waste.

As with the organic contaminants, the occurrence of TCL inorganics in the soil/waste borings tended to be scattered, with a few localized areas of elevated concentrations, and with few exceptions, most occurred in the upper 0-2 ft samples. Table 17 contains the geometric mean concentration for elements detected in subsurface soil boring samples compared to the expected average for "natural soils" according to Lindsay (1979). The following elements were detected at geometric mean concentrations that were greater than what would be expected for natural soils:

Arsenic	Mercury
Cadmium	Selenium
Calcium	Silver
Lead	Zinc
Magnesium	

Table 18 contains the maximum concentration for metals detected in subsurface soil boring samples compared to the common range for "natural soils" according to Lindsay (1979) and Ohio farm soils (Logan and Miller, 1983). Average concentrations for other compounds are not available.

Of the 76 soil boring samples collected and analyzed for metals, the following elements were detected at concentrations in excess of the common range for natural soils:

- o Magnesium - 45 samples outside of range
- o Cadmium - 24 samples outside of range
- o Copper - 2 samples outside of range
- o Zinc - 2 samples outside of range
- o Lead - 1 sample outside of range

Based on Lindsay's "common ranges," two of the Round I soil boring locations had four elements above the common range. The samples and elements are as follows:

- SB-17 - Cadmium, copper, zinc, lead
- SB-20 - Lead, magnesium, zinc, copper

The areal distribution of cadmium (Figure 34) was similar to that of other metals detected on-site. However, with the exception of SB-17 and SB-17A where concentrations were greater at the 5- to 6-ft depth, the concentration of cadmium with depth tended to be uniform suggesting that the levels detected are "background" for the site. Figure 35 shows the distribution of zinc at soil boring locations. Zinc was detected at 72 of 74 soil sampling locations and while the maximum concentration of zinc was at SB-17A at 5 ft (3,000 mg/kg), the geometric mean for zinc was 56 mg/kg. Concentrations of zinc in soil tended to decrease with depth.

A second soil boring (SB-17A) was conducted during Phase II adjacent to SB-17. Split spoon samples at 5-ft and 10-ft depths were submitted to the laboratory for metals analysis to confirm Phase I results. Data from SB-17A (Appendix J) confirm the elevated metal concentrations detected at SB-17 during Phase I.

Total cyanide was detected at all but 4 of the 26 Phase I soil boring locations, and in 51 of the 74 samples collected. Concentrations detected varied from 2.7 mg/kg (SB-3 at 6 ft) to 111 mg/kg (SB-12 at 2 ft), but the geometric mean was only 12 mg/kg (Table 15). The higher concentrations of total cyanides tended to be detected in the upper 2-ft soil samples and from generally the same locations as elevated metal concentrations.

4.2 Surface Soils.

The surface soil samples were collected in areas that have since been disturbed (not excavated) during the removal activities conducted in the fall of 1988. Therefore, surface soil data do not necessarily represent current site conditions. For this reason, 0-2 ft sample results from the soil borings were referenced in the Endangerment Assessment (Chapter 6.0).

Surface soil samples were collected from 6 on-site locations (Figure 8) in March of 1988. Results of analyses are contained in Appendix J. Table 19 summarizes frequency of detection, minimum and maximum concentrations, and geometric mean for the EPA TCL parameters in surface soil samples.

4.2.1 Organic Character - Surface Soils.

4.2.1.1 Volatiles.

Volatiles were only detected at very low levels in surface soil samples with the highest concentration of any compound being the detection of total xylenes of 330 ug/kg. Chloroform was detected in surface soil samples, occurring in SS-1 through SS-5 at a concentration range of 6.0 ug/kg to 22 ug/kg. Trichloroethene and total 1,2-dichloroethene were only detected at SS-5 at 6.0 ug/kg and 19.0 ug/kg, respectively.

4.2.1.2 Semi-Volatiles.

Bis(2-ethylhexyl)phthalate (DEHP) was detected in all but one (SS-1) surface soil. However, with the exception of SS-5 (16,000 ug/kg) and SS-6 (6,600 ug/kg), concentrations of DEHP were less than the Contract Required Quantitation Limit (CRQL) of 330 ug/kg. Butylbenzylphthalate was detected in one sample (SS-4) at 140 ug/kg (CRQL = 330 ug/kg) with DEHP. Phthalates are typical lab and sampling contaminants, and measured concentrations near or below CRQL may be attributed to this.

PAHs were detected at two surface soil locations: SS-6, where phenanthrene and 2-methylnaphthalene were detected at a total concentration of 44,000 ug/kg, and at SS-5 where pyrene was detected at 1,400 ug/kg.

4.2.1.3 Pesticides/PCBs.

Gamma-chlordane was the only pesticide detected in surface soil samples. This compound was detected at location SS-6 at a concentration of 420 ug/kg.

Aroclor 1248 was detected in the following surface soil samples:

<u>Location</u>	<u>Concentration (ug/kg)</u>
SS-2	150
SS-3	3400
SS-4	3200
SS-5	2400

4.2.2 Inorganic Character - Surface Soils.

Table 20 contains the geometric mean concentration for elements detected in surface soil samples compared to the expected average for "natural soils" according to Lindsay (1979). In general, the surface soils are very similar to subsurface soil, though the geometric means of most compounds are higher. This could be expected considering that the elevated levels of metals in subsoils were generally in the upper two feet. The following elements were detected at geometric mean concentrations that were greater than what would be expected for natural soils:

Arsenic	Mercury
Cadmium	Nickel
Lead	Silver
Magnesium	Zinc
Manganese	

Table 21 contains the maximum concentrations for elements detected in surface soil samples compared to the common range for "natural soils" according to Lindsay (1979). Of the 6 surface soil samples collected, the following elements were detected at concentrations in excess of the common range for "natural soils":

o	Cadmium	- 6 samples outside of range
o	Zinc	- 2 samples outside of range
o	Magnesium	- 2 samples outside of range
o	Chromium, total	- 1 sample outside of range
o	Copper	- 1 sample outside of range
o	Lead	- 1 sample outside of range
o	Nickel	- 1 sample outside of range
o	Silver	- 1 sample outside of range

Based on Lindsay's common range for "natural soils," cadmium, total chromium, copper, lead, magnesium, silver and zinc were above the common range at surface soil location SS-5.

Total cyanide was detected in all 6 surface soil samples with the geometric mean concentration being 112 mg/kg. With the exception of SS-5, concentrations ranged from 30.4 mg/kg at SS-6 to 148 mg/kg in the sample duplicate for SS-4. The highest cyanide concentration measured in surface soil (1900 mg/kg) was in the sample from SS-5, the same location as were elevated metals.

4.3 Groundwater Quality.

Round I groundwater samples were collected between March 14, 1988 and March 18, 1988 from 17 wells. Round II groundwater samples were collected from 21 monitoring wells, 2 municipal water supply wells and 2 private residential wells in the vicinity of the WRR Site, between August 30, 1988 and September 13, 1988. Round I and II groundwater monitoring well samples were analyzed for TCL Volatiles, Semi-Volatiles, pesticide/PCBs, dissolved metals and indicator compounds; municipal and private wells were analyzed for the same parameters except samples were not filtered for metals analysis. Results from Round I and II analyses are contained in Appendix J.

Table 22 and 23 summarizes frequency of detection, minimum and maximum concentration, and geometric mean for EPA TCL parameters detected in monitoring well samples during Rounds I and II. Table 24 and 25 summarizes chemical data for municipal and private water supply wells.

The following discussion encompasses the organic and inorganic character of the groundwater in the upper and lower aquifer, and a comparison with the soil/waste character.

4.3.1 Organic Character - Groundwater.

As with the subsurface soil boring data the occurrence of TCL organics in the upper aquifer was primarily associated with localized discontinuous areas of chlorinated ethene. These areas are shown on Figure 36 and consist of:

- o an area around MW-7,
- o an area around MW-9,
- o an area around MW-14, and
- o an area in the vicinity of MW-3 and MW-10.

4.3.1.1 Volatiles.

Chloroform (2.0 ug/L in MW-1D (CRQL = 5 ug/L)) was the only volatile organic compound detected in samples from monitoring wells screened in the lower aquifer (MW-1D, MW-8D and MW-13D). 1,1,1-Trichloroethane was detected at 1 ug/L in the old packing house well (PH) during Round II of groundwater sampling. The PH well is screened in the lower aquifer; however, well construction is unknown and the representativeness of the lower aquifer conditions at this well is questionable. No volatile compounds were detected in municipal or private water supply wells. The following section discusses the distribution and concentration of volatile organics in the upper aquifer.

Chlorinated ethenes were most widely distributed organic contaminant in the groundwater system occurring in approximately half of the Round I and Round II groundwater samples (Figure 36). Total chlorinated ethenes were detected in 8 of 17 Round I samples and in 13 of 21 Round II samples. However, the highest concentrations of total chlorinated ethenes for both Round I and II were detected at three discontinuous locations:

- o in samples from MW-3S (25,300 ug/L Round I and 7,347 ug/L Round II) and MW-10S (61,500 ug/L Round I and 28,822 ug/L Round II) in the southeast corner of the Site,
- o in MW-9S (51,000 ug/L Round I and 63,824 ug/L Round II) between the process building and the Blue River, and
- o MW-7S where chlorinated ethenes were 2,700 ug/L in Round I and 1,900 ug/L in Round II. Figure 36 shows monitoring well locations and total chlorinated ethene concentrations for both Round I and II.

Vinyl chloride was the most frequently detected chlorinated ethene, occurring in 41% of Round I samples and 57% of Round II samples at geometric mean concentration of 56 ug/L and 36 ug/L, respectively. Total 1,2-dichloroethene, while occurring less frequently (29% in Round I and 48% in Round II), was detected at considerably higher concentrations in both Round I (5,551 ug/L, geometric mean) and in Round II (460 ug/L, geometric mean). Trichloroethene was detected once during Round I (18,000 ug/L at MW-9S) and three times during Round II (maximum concentration 25,000 ug/L at MW-9S).

Tetrachloroethene was detected once in Round II at 27 ug/L in MW-9S, and 1,1-dichloroethene was detected three times in Round II at a maximum concentration of 92 ug/L at MW-9S.

Chlorinated ethenes can be biologically degraded to successor compounds, following the sequence given below:

- o tetrachloroethene (PCE)
- o trichloroethene (TCE)
- o 1,2-dichloroethene (DCE)
- o vinyl chloride

The degradation of DCE to vinyl chloride appears to be the slowest step in the sequence. The predominance of the DCE component of the chlorinated ethene group in groundwater samples possibly indicates anaerobic biological

degradation is occurring. This may be the situation that is occurring in the data from MW-7. A series of four soil borings (SB-2, SB-002E, SB-002W, and SB-002S) were drilled at this location. With the exception of the samples from SB-2, the only compounds detected in soil samples were tetrachloroethene and trichloroethene. However, the only volatile compound found in the groundwater in MW7S was 1,2-dichloroethene. In addition, the only volatile found in MW4S, located approximately 200 feet downgradient, was vinyl chloride.

A comparison of total chlorinated ethene concentrations based on Round I and Round II data indicates a decrease in all wells with the exception of MW-9S and MW-1S, where concentrations increased slightly. The following is a summary of total chlorinated ethene concentrations and percent decrease between Rounds I and II.

	<u>Round I</u>	<u>Round II</u>	<u>Percent Change</u>
MW- 3S	25,300	7,347	- 71%
MW- 4S	5.0	2.0	- 60%
MW- 7S	2,700	1,901	- 30%
MW-10S	61,500	28,822	- 53%
MW-11S	48.0	22.0	- 54%

The decrease in total chlorinated ethene concentration in the groundwater samples was reflected evenly between the dominant constituents, vinyl chloride and total 1,2-dichloroethene, and generally did not affect the distribution between successive components. In general, contaminant loadings in groundwater fluctuate with rising and falling groundwater levels. In the spring, as rainfall infiltrates through contaminated soils and higher water levels allow more groundwater to be in contact with contaminated soils, contaminant loads increase. Throughout the summer they probably decline and then may increase again in the fall. This normal fluctuation may have been exaggerated by the drought conditions that existed in 1988. No change in areal distribution of the chlorinated ethenes was indicated by Round I and II data.

Total chlorinated ethanes were detected much less often and at considerably lower concentrations than the chlorinated ethenes. 1,1-Dichloroethane was the only chlorinated ethane detected in Round I groundwater samples, occurring at MW-10S at a concentration of 630 ug/L. Chlorinated ethanes were detected in 8 of 21 Round II samples with the maximum detected concentration at MW-14S (276 ug/L) in the southwest corner of the Site. The dominant chlorinated ethane constituent was 1,1-dichloroethane. As with the

chlorinated ethenes, bacterial activity can prompt the degradation of 1,1,1-trichloroethane to 1,1-dichloroethane which may degrade to chloroethane.

Toluene was detected in only 3 samples and only during Round II sampling. The highest concentrations were detected in MW-10S (3,500 ug/L) and MW-9S (21 ug/L). Benzene and ethylbenzene were also detected in MW-10S at concentrations of 7.0 ug/L and 4.0 ug/L, respectively.

4.3.1.2 Semi-Volatiles.

Phenols were only detected in three of 17 Round I monitoring well samples and in 4 of 21 Round II monitoring well samples. With the exception of MW-10S, concentrations of total phenols in Rounds I and II samples were less than the CRQL of 10 ug/L, as follows:

<u>Well</u>	<u>Round I Total Phenols (ug/L)</u>	<u>Round II Total Phenols (ug/L)</u>
MW- 3S	2	3.6
MW- 9S	5	6
MW-10S	37	43
MW-83B	--	6

Phenol was detected in one of the municipal well samples at a concentration of 2 ug/L (CRQL = 10 ug/L).

Phthalates were detected in three Round I monitoring well samples and seven Round II monitoring well samples. Low concentrations of phthalates (CRQL = 10 ug/L) for individual constituents may be attributed to sampling or laboratory contamination therefore, the data does not suggest that phthalates are a problem. Concentrations of total phthalates in Round I and Round II samples were as follows:

<u>Well</u>	<u>Round I Total Phthalates (ug/L)</u>	<u>Round II Total Phthalates (ug/L)</u>
MW-83A(D)	4	2.3
MW-83D	29	6
PH	27	160
MW-7S	--	0.3
MW-9S	--	0.6
MW-10S	--	6
MW-83B	--	32

Bis(2-ethylhexyl)phthalate was the dominant phthalate constituent detected in all wells, with the exception of 83A(D) where diethylphthalate was at a higher concentration.

Diethylphthalate was detected in both municipal well samples (0.2 ug/L and 0.3 ug/L) and in one private well (2.0 ug/L). Di-n-octylphthalate was detected in one monitoring well at 3 ug/L, and butylbenzylphthalate was detected in a private well at 0.2 ug/L. The low concentrations of phthalates in water samples (CRQL = 10 ug/L) are possible sampling or laboratory contaminants.

The only constituent of the PAH group detected in groundwater was naphthalene, below CRQL, at a concentration of 0.08 ug/L in MW-83D (round I) and 0.1 ug/L in MW-83B (Round II).

4.3.1.3 Pesticides/PCBs.

No pesticides or PCBs were detected in groundwater samples.

4.3.2 Inorganic Character - Groundwater.

Calcium, magnesium, sodium and potassium are major constituents common to naturally occurring groundwater (see Table 26). Iron and potassium are minor constituents in naturally occurring groundwater (Table 26). The remaining elements are considered trace constituents in naturally occurring groundwater (see Table 26). Aluminum, barium and manganese occur in natural waters at concentrations less than 100 ug/L (Table 26).

Aluminum was detected at concentrations greater than 100 ug/L in two Round I samples (MW-83D at 30,200 ug/L and MW-83A(S) at 871 ug/L), and in four Round II samples (MW-83D at 23,800 ug/L, MW-83A(S) at 2,460 ug/L, MW-8S at 467 ug/L and MW-9S at 150 ug/L). The elevated aluminum concentrations measured at MW-83D during Rounds I and II sampling appear to be related to the high pH (11.63) at this location (Appendix J). The high pH at MW-83D may be the result of the possible use of cement-bentonite grout in existing wells. Aluminum solubility is enhanced at high or low pH. Round II results for MW-83D again showed elevated pH (11.21). Barium was detected in excess of 100 ug/L in 18 Round I samples and 11 Round II samples. Maximum barium concentrations for both Rounds I and II occurred in MW-1S (1,870 ug/L and 1,370 ug/L respectively). Barium was detected at concentrations greater than 100 ug/L in both municipal wells (126 ug/L and 150 ug/L) and both private wells (111 ug/L and 215 ug/L). Manganese exceeded 100 ug/L in all but four samples (MW-5S-Rounds I and II, MW-7S-Round I, and MW-83A(S)-Round II). Arsenic was detected at concentrations above CRDL (10.0 ug/L) at 4 monitoring well locations; MW-03S (15.0 ug/L and 23.4 ug/L; Rounds I and II respectively), MW-08S (15.0 ug/L; Round II), MW-095 (10.7 ug/L; Round II) and

MW-83D (57.1 ug/L and 20.0 ug/L; Rounds I and II respectively). As with aluminum, elevated arsenic concentrations at MW-83D may be attributed to abnormal pH conditions in this well.

Total cyanide was detected in 11 of 17 Round I monitoring well samples and 14 of 21 Round II samples. Geometric mean concentrations of total cyanide in the groundwater samples were 35 ug/L in round I and 25 ug/L in Round II. Individual cyanide results between sampling Rounds and sample duplicate varied somewhat. Total cyanide exceeded 102 ug/L in 4 Round I samples, but was either not detected or considerably less in Round II during which only one well (MW-12) installed during Phase II had concentrations exceeding .100 mg/L.

4.3.3 Comparison with Soil/Waste Character.

4.3.3.1 Organics.

The chlorinated ethenes were most frequently detected and were detected at the highest concentration of target organics in both soil/waste and groundwater media. The concentrations of chlorinated ethenes in soil borings tended to increase with depth. The highest concentrations were located in the southeast corner of the Site, between the process building and the Blue River along the southern border and to a lesser degree in at the north central border of the site. These locations correspond with locations having the maximum concentrations of ethenes detected in groundwater samples. The vertical distribution of chlorinated ethenes in the vadose zone and the correlation between areas of maximum concentration indicate that chlorinated ethenes have migrated toward the water table.

The concentration of the chlorinated ethanes in the soil/waste and groundwater media, while less predominant than the chlorinated ethenes, tended to show similar trends in distribution.

Toluene was widely distributed at the site with the majority of the detects at relatively low concentrations. The maximum concentrations were observed in the southeast corner of the Site. The areal extent of measured toluene in groundwater was much less than that of the soil/wastes, and was detected mainly in the southeast corner of the Site.

The phthalate group of compounds were the most frequently detected semi-volatiles in both soil/waste samples and groundwater samples, although low concentrations may be attributable to sampling or laboratory contamination. Bis(2-ethylhexyl)phthalate (DEHP) was the dominant constituent compound in both media. No correlation in spatial distribution or maximum concentrations between media was apparent.

The PAH group of compounds were only found in isolated areas in site soils. Naphthalene was detected at very low concentration in two of the existing monitoring wells; however, there was no apparent correlation between the soil and groundwater for PAHs.

4.3.3.2 Inorganics.

Cadmium, copper, lead, magnesium, manganese and zinc were detected in soil boring samples at elevated concentrations (see Table 18). Of these elements cadmium was detected in only one groundwater sample (MW-5S). Cadmium was not detected in the soil boring for this well (SB-25). Copper was detected in groundwater samples; however, concentrations were less than those detected in field blanks. Lead was detected in two monitoring well samples, one of which may be in the vicinity of elevated soil concentrations. Magnesium is a major constituent of groundwater (see Table 26). Manganese was detected in the majority of monitoring well samples and in the off-site municipal and private well samples and is probably natural to the regional groundwater. For the most part, the highest levels of manganese were detected in the areas of other types of contaminants (MW-3, MW-7, MW-9, MW-12, MW-14). The only exceptions were elevated manganese concentrations at MW-8S, at 892 ug/L; and pH at 480 ug/L. Zinc was detected in a number of monitoring well samples, and in municipal and private wells. Figure 37 shows zinc concentrations at monitoring well locations during Round I and II. With the possible exception of MW-1S, concentrations of zinc in groundwater do not appear to be strongly correlated with soil concentrations.

Cyanide results for Round I groundwater and soil boring samples showed little correlation. Cyanide was detected at concentrations greater than 100 ug/L in 4 monitoring well samples GW-01S, GW-04S, GW-05S, and GW-07S. The corresponding soil borings for these wells are SB-018, SB-019, SB-025 and SB-002 respectively. Cyanide was detected in SB-018 samples at all three depths (2-ft, 6-ft, 10 ft) between 6.2 mg/kg and 14.4 mg/kg, and at SB-019 at 6 ft and 10 ft (13.2 mg/kg and 8.6 mg/kg). Cyanide was not detected at SB-025 or SB-002.

4.4 Surface Water Quality.

Surface water samples were collected in March 1988 at 13 locations adjacent to and on the WRR site (see Figure 9). Results of analyses are contained in Appendix J. Samples were not filtered prior to analysis. Results represent the sum of dissolved constituents, and constituents solubilized from suspended sediment. The surface water sample collected from the Blue River at SW-1, located approximately 400 feet north (upstream) of the north Site boundary, was considered as background for evaluation purposes.

Table 27 summarizes frequency of detection, minimum and maximum concentrations, and geometric mean for EPA TCL parameters in surface water samples.

4.4.1 Organic Character - Surface Water.

4.4.1.1 Volatiles.

Samples collected from the Blue River (SW-3, SW-4, SW-5, SW-6 and SW-7) contained total 1,2-dichloroethene at estimated concentrations ranging from 1.0 ug/L to 4.0 ug/L, but all concentrations were less than the CRQL of 5.0 ug/L. Total 1,2-dichloroethene was detected in only one on-site surface water sample (Figure 38), at a concentration of 1,600 ug/L detected at SW-12. 1,1-Dichloroethane was also detected in one surface water sample (SW-12), at a concentration of 66.0 ug/L. Methylene chloride was detected in one surface sample (SW-10) at 6.0 ug/L and may be attributed to laboratory contamination.

4.4.1.2 Semi-Volatiles.

All measured concentrations of semi-volatiles in surface water were less than the CRQL and estimated. Occurrence of phthalates may be attributable to lab or sampling contamination. The maximum concentration of semi-volatiles in surface water was detected in SW-10, where the total phthalate concentration was 1.4 ug/L. Diethylphthalate was detected in seven of the samples at concentrations ranging from 0.08 ug/L to 0.3 ug/L. Pyrene was detected in one sample, SW-3, at 0.1 ug/L.

4.4.1.3 Pesticides/PCBs.

No pesticides or PCBs were detected in surface water samples.

4.4.2 Inorganic Character - Surface Water.

Table 28 shows maximum and geometric mean concentrations of elements detected in surface water samples. TCL inorganic concentrations occurring in River water samples adjacent to and downstream from the Site (SW-2 through SW-7) differed little from those measured in the background samples from SW-1. Zinc was detected at slightly higher, yet still less than CRDL concentrations in samples from SW-2, SW-5, SW-6 and SW-9. The same was generally true for on-site surface water samples from SW-8, SW-11 and SW-13, when compared to SW-1. Slightly higher iron, manganese, potassium, sodium, zinc and total cyanide concentrations were observed in samples from SW-9, SW-10 and SW-12 when compared to other surface water samples. Additionally, slightly higher barium concentrations were observed in the sample from SW-9, and slightly higher arsenic concentrations were observed in the sample from SW-12; however, zinc, barium and arsenic were all below the CRDL.

Total cyanide was detected in all surface water samples, including SW-1. With the exception of samples from three on-site sample locations (SW-9, SW-10, SW-12), concentrations were between 20 ug/L (SW-8) and 38 ug/L (SW-6). Total cyanide concentrations at SW-9, SW-10 and SW-12 were 258 ug/L, 120 ug/L and 315 ug/L, respectively.

4.4.3 Comparison with Soil/Waste Character.

4.4.3.1 Organics.

As with soil/waste samples, the most frequently detected volatile in surface water was total 1,2-dichloroethene.

The phthalate group was the most frequently detected semi-volatile in both soils and surface water samples; however, the dominant constituent in surface water was diethylphthalate, while bis(2-ethylhexyl)phthalate was dominant in soils.

4.4.3.2 Inorganics.

Cadmium, copper, lead, magnesium, manganese and zinc were detected in soil boring samples at elevated concentrations (see Table 18). In surface water samples:

- Cadmium was not detected.
- Copper was detected below CRDL at 10 of 13 locations, including background (SW-1).

- Lead was detected at three locations, SW-9, SW-12 and SW-13.
- Magnesium is a major constituent of natural waters.
- Manganese may be naturally occurring at moderate concentrations; however, elevated levels at SW-12, SW-10 and SW-9 are in the vicinity of higher soil concentrations.
- Zinc was detected below CRDL at all surface water locations; however, concentrations were slightly higher at SW-2, SW-5, SW-6, SW-7, SW-9, SW-10 and SW-12.

Cyanide was detected at higher concentrations in 3 on-site surface water samples (SW-9, SW-10 and SW-12). Only the SW-12 sample was from a surface water location in the vicinity of elevated cyanide concentrations in on-site soils.

4.4.4 Comparison with Groundwater Quality.

No volatile organics were found above the contract required quantitation limit.

4.5 Sediments.

Sediment samples were collected concurrently with surface water sampling at surface water locations (see Figure 9). Results of analyses are contained in Appendix J. As with surface water samples, SD-1 was collected upstream from the Site and was considered as a background sample for evaluation purposes.

Table 29 summarizes frequency of detection, minimum and maximum concentration, and geometric mean for EPA TCL parameters in sediment samples.

4.5.1 Organic Character - Sediment.

4.5.1.1 Volatiles.

Chlorinated ethenes were the most frequently detected volatiles in sediment samples (Figure 38). Sediment samples from the Blue River had detectable levels of chlorinated ethenes at SD-3 (1,230 ug/kg), SD-4 (14.0 ug/kg), SD-5 (37 ug/kg) and SD-6 (7.0 ug/kg). Chlorinated ethenes were detected in on-site sediments at SD-12 (1,100 ug/kg), and at SD-11 (51.0 ug/kg).

Total 1,2-dichloroethene was the only constituent compound at SD-12, while tetrachloroethene (7.0 ug/kg) and trichloroethene (44.0 ug/kg) were the constituent compounds at SD-11. Vinyl chloride was detected only in SD-3 (270 ug/kg).

Chlorinated ethanes were detected at only 3 sediment locations: SD-3 (1,300 ug/kg) as 1,1-dichloroethane; SD-12 (33.0 ug/kg) as 1,1-dichloroethane; and SD-11 (3.0 ug/kg) as 1,1,1-trichloroethane. Toluene was detected in two sediment samples: SD-8 (150 ug/kg) and SD-13 (210 ug/kg). Ethylbenzene was detected in 3 samples: SD-9 (33 ug/kg); SD-10 (3.0 ug/kg); and SD-13 (3.0 ug/kg). CRQL for the above compounds are 5.0 ug/kg.

4.5.1.2 Semi-Volatiles.

All semi-volatile compounds detected in sediment samples were below CRQL of 330 ug/kg. Bis(2-ethylhexyl)phthalate (DEHP) was the most frequently detected and highest concentration of the three semi-volatiles in found sediment samples. DEHP was detected in 10 of 18 sediment samples at concentrations ranging from 59 ug/kg in SD-2L to 220 ug/kg in SD-11 (DEHP was also detected in SD-12 at 200 ug/kg). Di-n-butylphthalate was detected in SD-1R at 27 ug/kg (DEHP was at 99 ug/kg at this location). 4-Methylphenol was detected at 86 ug/kg at SD-1L, approximately 400 feet upstream from the Site boundary. As with surface water samples, low concentrations of phthalates may be attributed to lab or sampling contamination.

4.5.1.3 Pesticides/PCBs.

Aroclor 1254 and 1260 were detected in sediment samples slightly above the CRQL of 160 ug/kg. Aroclor 1254 was detected in river sediments at locations SD-3 (200 ug/kg) and SD-5 (290 ug/kg). Aroclor 1260 was detected in the drainage swale at location SD-14 (200 ug/kg).

4.5.2 Inorganic Character - Sediments.

Concentrations in river sediments locations were not significantly greater than at SD-01 (400 ft upstream). Of the river sediment samples, the elements detected at concentrations considerably higher than in the background sample from SD-01 were copper and zinc. Slightly higher concentrations of total cyanide were detected in 6 of 9 downstream sediment samples (SD-02R, SD-03, SD-05, SD-06, SD-07L and SD-07R). The highest river sediment cyanide concentration was 38.6 mg/kg at SD-07R, compared to 25.5 mg/kg at SD-01. Concentrations at some on-site sediment sampling locations were higher than at station SD-01. Aluminum was detected at SD-09 (8,510 mg/kg) and SD-11 (9,920 mg/kg) compared to 6,860 mg/kg at SD-01R. Arsenic was detected at SD-08 (12.4 mg/kg), SD-09 (19.7 mg/kg), SD-10 (15.9 mg/kg) and SD-11 (19.0 mg/kg) compared to 9.6 mg/kg at SD-01R. Barium was at 80.1 mg/kg (SD-09) and 71.0 mg/kg (SD-11) compared to 64.1 mg/kg at SD-01R. Chromium was at 15.0 mg/kg (SD-09) and 39.5 mg/kg (SD-11) compared to 13.5 mg/kg at SD-01R.

Copper at SD-09 (38.2 mg/kg), SD-10 (26.8 mg/kg) and SD-11 (47.5 mg/kg) compared to 21.2 mg/kg at SD-01R. Manganese at SD-10 (456 mg/kg), SD-11 (629 mg/kg) compared to 443 mg/kg at SD-01R. Zinc at SD-09 (103 mg/kg) and SD-11 (397 mg/kg) compared to 68.3 mg/kg at SD-01R. Cyanide was detected at concentrations above those at SD-01R (25 mg/kg) at SD-08 (58.6 mg/kg), SD-09 (38.7 mg/kg), SD-11 (47.7 mg/kg) and SD-14 (66.4 mg/kg).

5.0 CONTAMINANT FATE AND MIGRATIONS

This chapter assesses current and potential contaminant migration from waste and soil materials at the WRR Site, into off-site surface water, sediments, and/or groundwater. The migration of contaminants within given media are also evaluated as are contaminant fate and persistence.

5.1 Potential Routes of Migration.

5.1.1 Soil/Waste.

Analytical results of soil samples collected during subsurface soil boring and surface sampling activities are contained in Appendix J and are summarized in Tables 15, 16 and 19.

The predominant contaminants in the soil at the WRR Site are chlorinated ethenes, toluene, phthalates, metals (cadmium, copper, zinc, lead) and cyanide. To a lesser extent, PAHs, pesticides and PCBs were also detected in soil samples from the site.

5.1.1.1 Migration.

The distribution of the contaminant in the surface and subsurface soils will influence potential migration. The chlorinated ethenes were predominantly found at or near the base of the vadose zone and were generally located along the southern and southeastern boundary of the site. Toluene was widely distributed at the site with the majority of the detects at relatively low concentrations. As with chlorinated ethenes, the higher concentrations were in the southeast part of the site. PAHs, metals and cyanide tended to be at or near the surface and were centrally located on the site with distinct "hot spots". The phthalate group of compounds were randomly distributed both vertically and areally within the soils, and the pesticide/PCB group occurred randomly at or near the surface.

The primary means of transporting contaminants associated with surface soils at the WRR site appears to be surface water runoff and erosion. Airborne dust while not a major transport factor on-site due to vegetative cover, may be a factor along roadways and in disturbed areas. Movement of soil by water is dependent upon several factors, including the nature of erosive forces (rainfall amounts and intensities), physical properties of the soil (degree of compaction, soil structure, infiltration rates), and surface conditions (vegetation cover, slope, and surface roughness). Surface topography,

vegetative cover and soil composition vary somewhat over the site, however, the primary potential route for off-site migration of surface contamination is through the Blue River. Total on-site surface areas subject to drainage into the Blue River has been estimated at approximately 4.44 acres (Beranek, 1984). This drainage area is primarily composed of steep, vegetated river bank and the facility operations parking lot and buildings.

The remainder of on-site surface water apparently drains into surface depressions and ponds and is lost to groundwater drainage and evaporation (Beranek, 1984).

Percolation and groundwater recharge appear to be controlling transport factors with the subsurface contaminants. Migration of contaminants from surface to subsurface soils and groundwater occurs through leaching. Release of contaminants from surface to subsurface soils occur during rainfall and snowmelt events.

The areas most prone to downward migration on-site are areas where runoff is collected (i.e. the ponds and topographic depressions) including the former river bed and the southeast area (Figure 3). The southeast area coincided with one of the areas of higher volatile concentrations on-site.

5.1.1.2 Attenuation.

Adsorption of organic contaminants by soil particulates and/or waste materials can be a major attenuation mechanism for contaminated groundwater. Natural organic matter content, clay and soils in surface and subsurface soils of the vadose zone may limit the downward migration of certain organic contaminants. Results of laboratory soil analysis (Table 3) indicate the presence of silt and clay in the vadose zone at the site indicating the potential for contaminant attenuation; however, in localized areas of high contamination, the attenuation capacity of the soils may be exceeded.

Biochemical degradation of organic contaminants in the vadose zone and into the saturated zone is a potential attenuation process. Breakdown of chlorinated ethenes and chlorinated ethanes is suspected based upon relative concentrations of these compounds and potential by-product compounds in soil and groundwater samples. Volatilization of materials from the water table into the unsaturated zone and ultimately to the atmosphere may be a mechanism for release of materials. The shallow depth to groundwater probably enhances passage of soil vapors to the atmosphere.

The attenuation of metals and cyanide through the surface and subsurface soils will be influenced as above by the adsorption on organic matter and clay minerals present in the vadose and saturated zones. Adsorption of metals onto hydrous oxides of iron, aluminum and manganese may, depending on soil pH, contribute significantly to attenuation of contaminant migration at the site.

5.1.2 Groundwater.

This section describes potential groundwater migration routes for contaminants detected at the WRR Site. Analytical results for analyses of groundwater samples collected during Rounds I and II are contained in Appendix J and are summarized in Tables 22 and 23.

The major contaminants in the upper aquifer are the chlorinated ethenes, and as with the soils of the vadose zone, maximum concentrations occurred in discontinuous localized areas in the southeast former flood plain, between the process building and Blue River and at the north central boundary of the site. To a considerably lesser extent phenols, phthalates and metals (aluminum, barium, cyanide, manganese, arsenic and zinc) were detected in groundwater.

The data from wells screened in the lower aquifer indicate that little if any contaminant migration has taken place through the aquitard at the base of the upper aquifer. The only volatile organic compounds detected in lower aquifer wells were 1.0 ug/l of 1,1,1-trichloroethane at the old packing house well (PH) in Round II and 2.0 ug/l of chloroform at MW-01D. Both results are below CRDL. At well PH, 1,1,1-trichloroethane was only detected during Round II and construction details of the well are unknown. At MW-01D, chloroform is likely a laboratory contaminant, it was only detected at very low concentrations in two shallow wells and was detected in three trip blanks.

The migration of the relatively mobile volatile organic contaminants in the upper aquifer would tend to follow the general groundwater flow from west to east, and eventually discharge into the Blue River. There is the potential that some groundwater in the upper aquifer does not discharge to the Blue River but passes beneath the river. However the results of groundwater monitoring indicate that there may be little potential for the migration of contaminants beneath the river. An area of elevated VOC contamination on the site is shown to be in the upper aquifer in the vicinity of monitoring well MW-10S in the southeast area (Figure 36). Groundwater flow in this area is from west to east (Figures 20 and 21). When the monitoring results at MW-10S

are compared to those at MW-11S, approximately 250 feet to the east, it is apparent that there is either very little migration of contaminants with the groundwater flow or there is very high attenuation occurring (Figure 36). In either case, the concentration of VOC, (which are relatively conservative as solutes), decreases by more than three orders of magnitude in the 250 feet between MW-10S and the river (represented by MW-11S). Assuming that the same fate process occurs as groundwater flows to the east beneath the river, it is unlikely that VOC or other contaminants would be detected in the upper aquifer on the east or south side of the Blue River.

The potential for future increases in concentrations of chlorinated ethenes and ethanes in groundwater through migration from the upper 10 feet of the vadose zone toward the water table appears to be small for the following reasons:

- o Concentrations of the chlorinated ethenes and ethanes in the subsurface soils increase with depth toward the water table.
- o The 3 areas of highest soil concentrations (sources) were consistent with the highest groundwater concentrations.

The above indicates that most of the chlorinated ethenes and ethanes have moved to the water table and there appears to be no highly contaminated volatile organics source near the surface in the vadose zone.

The occurrence of phthalates (possible sampling or laboratory contaminants) and phenols in the groundwater samples were at relatively minor concentrations (compared to volatiles) and did not appear to correlate to soil concentrations and locations.

No pesticide/PCB's or PAHs (above CRQL) were detected in groundwater. The attenuation capacity of the soils and low solubility appears to prevent the migration of these contaminants to the groundwater.

The migration of inorganic contaminants in groundwater is affected by many factors related to the geologic matrix and hydrochemical environment (e.g., pH, pE, complexing to ligands, competing ions, nature of adsorbents). Predicting the transport and fate of trace metal contaminants in groundwater is difficult, however, the following observations at the WRR site can be made:

- o General water quality data (Appendix J) indicates sufficient alkalinity, chloride and sulfate to form complex hydrogeologic species with some of the trace metals, could lead to potential increased solubility and reduced adsorption of inorganic contaminants.
- o Elevated chloride concentrations in groundwater at MW-7S, MW-1S and MW- 1I could promote increased solubility (by the above processes) of metal contaminants in these locations.
- o The relative abundance of aluminum, iron and manganese at the site may enhance the adsorbent capacity of clay-size materials in the aquifer through the formation of hydrous oxide coatings. This would tend to limit the migration of trace metal contaminants through zones where clay-size particulates constitute a significant portion of aquifer materials (i.e., the flood plain in the upper aquifer, and the aquitard between the upper and lower aquifer).

5.1.2.1 Summary of Migration Potential - Groundwater.

The volatile organics (chlorinated ethenes, chlorinated ethanes, toluene) are currently the predominant contaminants in localized areas of groundwater at the site. Volatile migration (with the possible exception of toluene) into the groundwater from the vadose zone appears to have already occurred to some extent. Attenuation of volatile organics from areas of highest contamination (MW-10S, MW-3S) downgradient toward the to River (MW-11S) appears to be occurring.

Based on the data collected, the extent of trace metal contamination of groundwater at the site appears to be limited and localized; primarily to the north-central portion of the site (MW-1S) in the upper aquifer. The data indicate that little if any lateral or downward migration of inorganics has taken place. Future potential for downward migration into, and lateral migration within, the groundwater is difficult to predict however, it appears to be minimal. Downward and lateral migration of inorganics will be limited in the southeast area, and across the aquitard where clay-size particulates are significant.

5.1.3 Surface Water.

Analytical results of surface water samples are contained in Appendix J and are summarized in Table 27.

Surface water exists on-site as ponds and topographic depressions that, with the exception of a flood event, hold little potential for off-site migration. Of greater concern is the Blue River which borders the site on the east and south. The Blue River poses the greatest potential for off-site migration of contaminants. Therefore, this section discusses primarily current and potential contaminant migration in the Blue River.

Contaminant migration off-site into the river may occur by several processes:

- o Overland erosion of surface soils and contaminants into the river during periods of intense and/or prolonged atmospheric precipitation. Approximately 4.5 on-site acres drain to the river (Beranek, 1984).
- o Erosion of steep river banks during high water or flood conditions (a portion of the site also falls within 100 year flood plain) could cause contaminated soils and wastes to come into contact with river water.
- o Physical, chemical and/or biological changes in sediments or river water could lead to the aqueous solution of contaminants bound in sediments (this will be discussed in Section 5.1.4).
- o Discharge of contaminated groundwater to the river.

5.1.4 Evaluation of Current Surface Water Quality.

The chlorinated ethenes were detected in river water samples at relatively low concentrations (below CRQL). The only contaminant in surface water samples from the river was total 1,2-dichloroethene (of the chlorinated ethene group). Total 1,2-dichloroethene is first detected in the river at SW-3 (1.0 ug/L) east of the site and downgradient to the highest area of chlorinated ethene contaminated groundwater. Concentrations vary between 3.0 and 4.0 ug/L downstream, to SW- 7, 400 ft downstream from the Site boundary. All measured concentrations of 1,2-dichloroethene are estimated, as values were below CRQL.

The source of the total 1,2-dichloroethene concentrations detected in the river water samples is not known. Probable sources are discharge of chlorinated ethene contaminated groundwater or leaching from sediments that have been impacted in the past.

Surface water data from the river indicates that the other TCL compounds and elements detected adjacent to, or downstream from the site were at concentrations not considerably higher than those detected at SW-1, 400 ft upstream from the northern site boundary. However, as described above, there is potential for contaminant migration during and after periods of high rainfall, and during flood conditions. The potential fate of contaminants entering the river depends upon the chemical and physical properties of the compounds of concern, reducing or oxidizing conditions in surface water bodies, bioactivity, climatic conditions including seasonal variations, and dilution. Decreasing contaminant concentrations are expected with distance from the site due to attenuation. Dilution should occur when water levels rise due to added precipitation and/or as the surface water moves away from the site and joins other surface water bodies with background water quality.

5.1.5 Sediment.

Characterization of sediment contamination is discussed in Chapter 4. Results of sediment analyses are presented in Appendix J, and summarized in Table 29. Figure 9 shows sediment sampling locations.

As with the surface waters, the sediments that pose the greatest potential for off-site migration are within the Blue River. This section discusses potential migration of contaminants detected in the river sediments, and potential attenuation capacity.

Chlorinated ethenes and ethanes were detected in river sediments east and south of the site. The highest concentrations were at SD-3, downgradient of the area of volatile groundwater contamination on-site. A portion of the volatile organics detected in the sediments likely represents contamination in the discharging groundwater, but may be the result of past contamination of the sediments from another source. The transport of contaminants from groundwater discharge into surface water was discussed in Section 5.1.4.

The remaining organic contaminants detected in river sediments adjacent to the site included the phthalate group and PCBs. These compounds were not detected in surface water samples and may be preferentially adsorbed onto the sediments. Contaminant migration and fate in sediments is generally a function of surface water movement, river morphology and a number of physical, chemical and biological processes.

Only minor impacts to the river sediments with respect to inorganics have occurred. Slightly elevated copper, zinc and cyanide concentrations downstream and adjacent to the site were observed. For the most part, these chemicals would be expected to be adsorbed to sediments and follow the migration factors described below.

The capacity of the sediments to bind contaminants and retard contaminant migration is dependent on both chemical and physical properties of the sediment, and biological activity in the sediment. Retention of organics by sediment is typically attributed to adsorption by organic matter and precipitation. Oxides of iron, aluminum and manganese have an electrostatic attraction of ion charged mineral surfaces. Because reactions take place at the surface of particulates, particle size influences adsorption capacity on a per unit mass basis because of its effect on surface area. Large organic molecules tend to be adsorbed to a greater extent by organic matter than smaller ones. Metals may be complexed with organic matter, adsorbed by metal oxides and/or retained by ion exchange reactions. The relative importance of each factor varies with the particular metal. The electrochemical potential (Eh) of a system may also influence adsorption of inorganics by affecting the stability of iron and manganese oxides that serve as the sorbent. At low Eh, oxides may dissolve, resulting in release of adsorbed species.

Higher cation exchange capacity is a function of large amounts of surface area due to the small particle size of decomposed organic matter. The capacity for decomposed organic matter to bind contaminants is related to its high adsorption and cation exchange capacities. Many contaminants such as pesticides and heavy metals are tightly bound to soil constituents in organic soils. Sand particles are much larger and tend to have relatively low surface area for adsorption. Sandy sediments with small organic matter content retain less contaminant bound up on them.

The pH of the system, as influenced by the surface water quality, is a very important factor controlling the mobility and subsequent migration of contaminants in the sediments. pH influences the adsorbing properties of both the adsorber and the adsorbate. The pH levels reported in the field during river water and sediment sampling ranged from 7.37 to 8.15. The consistent pH levels along the river indicate the surface water mixing probably will not significantly alter pH levels and cause increased solubilizing of contaminants from sediments.

6.0 ENDANGERMENT ASSESSMENT

6.1 Introduction.

The potential threat to human health and the environment in the absence of any further remedial action is evaluated in the baseline endangerment assessment (EA) for the WRR Site. This evaluation provides information which will assist in determining whether or not additional remedial measures are necessary and provide justification for performing additional remedial actions. Preparation of the EA to assess the no-action alternative for the WRR Site uses the detailed guidance on conducting risk assessments provided in the Superfund Public Health Evaluation Manual (SPHEM) (U.S. EPA, 1986).

Endangerment assessments may be performed at various levels of detail. The assessment may range from a qualitative description of potential hazards through varying degrees of risk quantification. The level of detail required for sufficient demonstration of endangerment can vary depending on the intended use of the assessment, the amount and type of information available and the necessity to quantify certain aspects of risk at a given site. The assessment performed for the WRR Site is quantitative in that estimates of contaminant intake by applicable exposure pathways have been determined. In calculating receptor intake (human dose) of contaminants and quantifying toxicological hazards, analytical measurements were used from data generated as a result of remedial investigations. In some instances where analytical data were unavailable, contaminant concentrations have been projected using mathematical models to derive exposure point (human contact) concentrations.

Two health risk scenarios have been evaluated for the WRR Site. The first alternative assumes that current use and conditions prevail at the site and that no action is taken to remediate the site. Although extensive removal actions have previously been implemented and recent soil cleanup measures have been taken, this risk assessment uses the data generated during the remedial investigation performed by Warzyn as reported in this RI Report. The second alternative considers reasonable future use of the site assuming no remedial action and no institutional controls are placed on the site. Future use of the site could potentially have a wide variety of applications. Both the future use and current use scenarios are explained in greater detail in the Exposure Assessment section.

In general, the objectives of the EA may be attained by identifying and characterizing the following:

- o Identity and quantity of contaminants present in various media (e.g., air, soil, surface water, sediment and groundwater).
- o Contaminant toxicity.
- o Environmental fate and transport mechanisms including physical, chemical and biological properties that impact the contaminant(s).
- o Migration routes and potential exposure pathways (to receptors).
- o Potential receptors (i.e., human and environmental).
- o Potential for receptors to be impacted (exposed) and to what extent.
- o Comparison of exposures to "acceptable" levels based on available regulatory and toxicological information.

The following are components of the EA developed for the no-action alternative at the WRR Site:

- o Selection of Indicator Chemicals
- o Exposure Evaluation
- o Assessment of Toxicity
- o Characterization of Risks

This EA is structured to provide a sequential discussion of the components needed to assess the overall risk posed by no action at the site to mitigate release of contaminants to the environment. The evaluation process progresses from selection of chemicals which seem to pose the greatest threat and/or are representative of the compounds being released from the site, through determination of populations potentially exposed to releases, the potential toxicological effects to exposed populations and the risk to the exposed populations from the exposure.

6.1.1 Selection of Indicator Chemicals.

Because of the complexity of migration pathways and the large number of diverse potential contaminants detected in the various media (e.g., groundwater, soils, etc.) at the site, an indicator chemical selection process was used to reduce the number of chemicals to a manageable level for use in the EA. The selection of indicator chemicals is based on determination of which compounds potentially pose the greatest human and environmental health threat. Criteria included in the selection process incorporate an evaluation of each chemical's known toxicity, site concentrations and frequency of detection, and environmental mobility as reflected by the various physical and chemical properties of each chemical (i.e., K, solubility, vapor pressure, etc.).

6.1.2 Exposure Evaluation.

The exposure evaluation includes identification of actual or potential routes of exposure, characterization of the exposed populations (receptors) and a determination of the extent of exposure by estimating exposure levels (human intakes).

Populations which may come into contact with releases include human populations, sensitive subsets of human populations (e.g., children, elderly) and aquatic and terrestrial species which may be at risk. Because human health risks are determined on a lifetime basis (i.e., cancer potency slopes and chronic reference doses), various stages in a person's life are modeled. In this assessment, a 70-year lifetime is assumed to be comprised of 5 years as a toddler, 15 years as an adolescent and 50 years as an adult. Calculation of exposure doses for each stage in the life of an individual is initially done, so that a time-weighted average lifetime dose can be determined. This lifetime dose is then used to estimate the health risk.

To quantitatively assess health effects associated with releases from waste materials, the amount of contact with indicator compounds by the receptors was determined. Human exposure was determined in terms of a daily dose (the amount of substance absorbed into the body per unit body weight each day). Where appropriate, daily doses were calculated for multiple routes of exposure to a chemical or only for specific routes of exposure, if route specific toxic effects were noted.

6.1.3 Assessment of Toxicity.

The known and/or potential adverse health effects associated with exposure to each indicator chemical are identified. Toxicity data from epidemiological, animal, in vitro, and structure-activity studies in the scientific literature were evaluated and interpreted to provide a summary of potential health impacts. Dose-response relationships were established for both non-carcinogenic and carcinogenic effects of chemicals, where applicable.

6.1.4 Risk Characterization.

The risk characterization process integrates findings from the exposure assessment and toxicity assessment sections of this report. Estimates of excess cancer risk for carcinogenic chemicals are made by multiplying a carcinogenic potency factor (developed by U.S. EPA) by chronic exposure dose levels. Non-carcinogenic indicator chemical exposure levels are compared to reference doses for subchronic (RFDs) and chronic (RFD) effects as provided in the Superfund Public Health Evaluation Manual. Where RFD and RFDs are currently not available for indicator chemicals, they were derived. The basis and methodologies used for the derivation of the RFD and RFDs values are described for each chemical, where appropriate.

6.1.5 Background.

The previous chapters of the RI Report provide descriptions of the site location, history, and physical characteristics (i.e., geology, hydrogeology, etc.) and an evaluation of the chemical constituents found in the following media:

- o Groundwater
- o Surface water
- o Sediments
- o Subsurface soils
- o Surface soils

Reference to appropriate sections of the RI Report should be made as necessary for detailed descriptions of sample locations and the chemical and physical properties of the various media. Data presented in previous chapters of this RI Report have been evaluated and transformed in the EA to obtain estimates of public health risk.

6.2 Contaminants of Concern (Indicator Chemicals).

More than seventy-five chemicals from EPA's Target Compound List (TCL) and several tentatively identified compounds (TICs) were detected in samples taken during Phases I and II of the RI. The range of concentrations, geometric mean and the frequency of detection of these chemicals are presented by media in Tables 15, 16, 19, 22, 23, 25, 27 and 29. As suggested in the guidance provided in the SPHEM, a set of "indicator contaminants" were selected from these data bases. The contaminants selected are intended to represent several classes of contaminants that pose the greatest concern to human health or the environment.

6.2.1 Data Validity and Use.

Due largely to the difficulty in the analysis of chemicals from environmental media, the usability of the analytical results varied. Chemical concentration data were frequently estimated or in some cases determined to be unusable. Determination of data usability was accomplished at several levels. The contract laboratory included data qualifications assigned for various reasons indicating problems encountered during analysis. Data packages received by Warzyn from the contract laboratory (including raw data and quality control information) were then evaluated for usability by Warzyn quality assurance personnel. Guidance established by the U.S. EPA (1985, 1988) was used as the basis for this data validation. At this stage, data usability was determined from the standpoint of the quality of the analytical procedure as well as from consideration of potential problems associated with sampling procedures. Data presented in the Appendices show data qualifications assigned by both the contract laboratory and Warzyn.

Table 32 summarizes the definitions of data qualifiers for organic chemicals used in this report. Most frequently, data were determined to be estimated and qualified with "J." The degree of the uncertainty as well as the direction of the bias (under- or overestimation) associated with the data is not the same for each estimated value and is often difficult to ascertain for individual samples. Table 33 lists examples of conditions in which organic compound analytical results would be qualified as estimated. In this report estimated data were used with unqualified data for site analysis, since generally, inclusion of these values would result in a more conservative (highest) estimation of risks than considering these samples as having no detectable contaminants.

The usability of chemical concentration data which were detected in samples and associated method blanks was determined in accordance with U.S. EPA guidance (1985, 1988) as described below. The presence of common laboratory chemicals (methylene chloride, acetone, toluene, 2-butanone and common phthalates) were considered to be the result of laboratory contamination (flagged "UJ") if detected in the sample at concentrations less than or equal to 10 times the concentration detected in the associated method blank. All other compounds found in samples and method blanks were evaluated similarly, with the exception that a factor of 5 (instead of 10) was used to distinguish laboratory contamination. Field blanks were evaluated in the same manner as method blanks. Thus, if a compound was detected in a field blank, that compound found in associated samples was considered the result of sampling contamination if present in the sample at less than or equal to 5 times the concentration detected in associated field blanks. Data values determined to be the result of laboratory or field contamination were not incorporated in site analysis.

The following conditions were employed in the characterization of site risk: 1) when duplicate samples from a location were analyzed, only the highest value was used; and 2) during the multiple sampling rounds of the RI, several samples from the same location (e.g., monitoring wells and soil borings) were analyzed. As above, only the highest chemical concentration at each location was used for site analysis.

6.2.2 Procedures for Contaminant Selection.

After determination of criteria for data usage, the maximum and representative concentrations of each contaminant in each environmental medium at the site were determined. Determination of the maximum concentration was directly derived from the acceptable data within each set of results for the same media.

A geometric mean for each of the chemical contaminants was calculated to determine the representative concentrations in the following media:

- o Groundwater
- o Surface water (Blue River; on-site pond)
- o Sediment
- o Surface soils
- o Subsurface soils

After calculation of the geometric mean and identifying the maximum concentrations detected for each chemical in a given medium, the indicator selection process incorporated the following factors (based on professional judgment and guidance provided in SPHEM):

- o How often the chemical is found in each environmental medium;
- o What chemical group the chemical is in (the chemical groups for the WRR Site are volatiles, semi-volatiles, pesticides/PCBs and metals);
- o How hazardous the chemical is (i.e., indicator scores were calculated based on guidance in SPHEM - concentrations x available Toxicity Constants);
- o The presence of the chemical in relevant media (i.e., media with which receptors have exposure potential);
- o How many environmental media the contaminant is found in; and
- o Contaminant mobility/migration potential.

The pattern of contaminant distribution at the WRR Site indicates areas of discrete contamination rather than site-wide contamination. It is apparent from the data that many of the chemicals were detected infrequently and a particular chemical may have been detected only once or twice in an environmental medium. This pattern of contaminant distribution complicates the identification of chemicals which are representative of the potential exposures associated with the site. Selecting contaminants detected infrequently at the WRR Site may result in an overestimation of the potential hazards at the site. On the other hand, for a site such as the WRR Site, eliminating the infrequently detected contaminants may eliminate areas of the site that may pose discrete hazards.

Because of the prevailing pattern of contaminant distribution, the indicator selection process evaluated each contaminant relative to one another on a site-wide basis rather than as isolated areas of contamination.

The distribution of chemicals associated with on-site waste disposal indicate some migration through environmental media is occurring. Barring any further human disturbance (i.e., excavation of contaminated soils) or large-scale geologic or meteorologic events at the site, the migration of the site

contaminants will be controlled by site conditions and the inherent physical and chemical properties of the migrating compounds.

Because the mechanism of release and environmental transport of a chemical are such important events in an exposure pathway, the physical and chemical properties of each chemical at the site were integral components in the indicator selection process. The properties of indicator chemicals were used to approximate their behavior and migration. The physical and chemical properties of the indicator chemicals have been obtained from the literature, as appropriate, and approximated, if necessary. A discussion of the environmental significance of each of these parameters follows:

- o Specific gravity is the ratio of the weight of given volume of pure chemical at a specified temperature to the weight of the same volume of pure water at a given temperature. Specific gravity is primarily used to determine whether pure compounds, or very high concentrations of the compound, will float or sink in water in the absence of other forces.
- o Vapor pressure provides an indication of the rate at which a chemical volatilizes. It is of primary significance where environmental interfaces such as surface soil/air and surface water/air occur. Volatilization is not as important when evaluating groundwater and subsurface soils. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Vapor pressures for monocyclic aromatics (toluene) and chlorinated aliphatics (TCE) are generally many times higher than vapor pressure for phthalate esters (bis(2-ethylhexyl)phthalate), polynuclear aromatic hydrocarbons (PAHs), and pesticides.
- o The rate at which a chemical is leached from a waste by infiltrating precipitation is a function of its solubility in water. The more soluble compounds are expected to be leached much more readily and rapidly than less soluble chemicals. The water solubilities presented in the literature indicate that the volatile organic chemicals are usually several orders of magnitude more water soluble than the base/neutral organic compounds (e.g., PAHs, PCBs).
- o The octanol/water partition coefficient is used to estimate bioconcentration factors in aquatic organisms. A linear relationship between the octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor)

has been determined. It is also useful in estimating the sorption and desorption of compounds by organic soils, where experimental values are not available.

- o The soil/sediment adsorption coefficient is related to the water solubility and the octanol/water partition coefficient. This parameter indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high soil/sediment adsorption coefficients generally have low water solubilities. Chemicals with relatively high soil/sediment adsorption coefficients, such as phthalate esters, PAHs and PCBs are relatively immobile in the subsurface environment and are preferentially bound to the soil phase. Compounds with low solubility and high adsorption coefficients are not readily transported in groundwater and are generally not transported great distances if they are introduced in the groundwater system. Because the high adsorption coefficient compounds tend to be bound in soil and sediment particles, these immobile chemicals can be easily transported with soil particles by erosional processes. This parameter may be used to infer the relative rates at which the more mobile chemicals are transported in the groundwater.
- o Vapor pressure and solubility in water are of use in determining volatilization rates from surface water bodies for specific compounds. The ratio of the two values (Henry's Law constant) is used to calculate the equilibrium contaminant concentrations in the vapor (air) versus the liquid (water) phases for the dilute solutions commonly encountered in environmental settings.

Many of the site contaminants are volatile organic compounds. In general, volatile organic compounds (VOCs) and phenols have higher solubilities and higher vapor pressures than other site contaminants, such as phthalate esters, PCBs and PAHs. The physical properties of VOCs and phenols make them more susceptible to groundwater and atmospheric transport. Compounds in these classes tend to volatilize readily if they are present in surface soils or surface water. The high solubilities and low soil sediment adsorption coefficients of VOCs and phenols make them prone to leaching by infiltrating precipitation and transport to the groundwater system.

Base/neutral extractables such as PAHs and PCBs are relatively insoluble in water and have low vapor pressures. These characteristics are reflected in their higher soil/sediment adsorption coefficients. The primary mechanism by which the base/neutral extractables move in the environment is by erosion or

migration of soil or sediment particulates. Compounds such as PCBs and PAHs tend to have minimal migration, because they are not as susceptible to volatilization or solubilization, and generally are not major components of groundwater releases.

6.2.3 Final Determination of Indicator Chemicals.

Brief descriptions of the rationale used for the inclusion of the thirteen contaminants selected as indicators are presented in the following:

Vinyl Chloride was selected on the basis of its frequency of detection and elevated concentration in groundwater, both in Phase I and Phase II monitoring well sample results. Vinyl chloride is also considered a human carcinogen.

1,2-Dichloroethylene (DCE) was frequently detected in groundwater, surface water, sediment, surface soil and subsurface soil samples with concentrations ranging up to 82,000 ug/kg in soil samples (Phase II) and 56,000 ug/l in groundwater samples (Phase I).

Trichloroethylene (TCE) is an additional chlorinated volatile, selected based on its presence in groundwater, sediment, surface and subsurface soils. TCE is also a potential carcinogen. TCE was detected in elevated concentrations in groundwater (25,000 ug/l - Phase I) and in subsurface soils (83,000 ug/kg - Phase II).

Toluene is the fourth contaminant selected from the volatiles class. Toluene was found to be pervasive at the WRR Site and represents a volatile contaminant having a lower order of toxicity than the other volatiles.

bis(2-ethylhexyl)phthalate (DEHP) was selected to represent phthalates in the semi-volatile group of chemicals. Phthalates are highly pervasive at the site in soils and water. DEHP was selected to represent the phthalates because of its carcinogenic potential.

Polynuclear aromatic hydrocarbons (PAHs) were primarily found at one soil boring location (SB-18). However, PAH concentrations were elevated, and outside of the phthalates, were the only other semi-volatile group of contaminants judged to be of concern at the WRR Site, based on available data. Although PAHs were detected at a discrete location, their toxicity and concentration led to their inclusion as an indicator. This potential "hot spot" was not fully characterized due to limited sampling in the immediate

site. The PAHs are considered potential carcinogens that were used in the analysis consist of: Benzo (A) anthracene; Chrysene; Benzo (B) fluoranthene; Benzo (K) fluoranthene; Benzo (A) pyrene; and, Indeno (1,2,3-CD) pyrene.

Polychlorinated biphenyls (PCBs) were selected based on their presence in small localized areas in sediment and soils. PCBs have a high order of toxicity and although detected infrequently, PCBs were selected also to represent the organochlorine chemicals of the pesticide/PCB group from which no other chemicals were selected.

Cyanide and compounds were selected based on their high concentrations in soils and surface water. Although not a carcinogen, cyanide may be considered to be a potent non-carcinogen. Cyanide concentrations in surface water were found to exceed the Ambient Water Quality Criteria (AWQC) for the protection of humans at two surface water samples.

Arsenic, cadmium, chromium, nickel and zinc Metals were compared to average soil concentrations (Lindsay, 1979) and further screened by toxicity, concentration and pervasiveness. Cadmium, chromium, nickel and zinc were chosen to represent the metals group.

Exposures to the remaining chemicals detected at the WRR Site are not quantitatively evaluated in this risk assessment. Exclusion of these chemicals, on either a quantitative or qualitative basis, would not be expected to substantially alter the outcome of this risk assessment because these remaining chemicals were either detected at low concentrations, detected in a small number of samples, have a low order of toxicity or have been represented by one of the indicator chemicals selected for the respective chemical groups.

6.3 Toxicity Assessment.

The toxicological evaluations presented characterize the inherent toxicity of a compound. The evaluations consist of a review of scientific data to determine the nature and extent of the human health and environmental hazards associated with exposure to the various chemicals. The end product is a toxicity profile for each indicator chemical. These toxicity profiles provide the qualitative weight-of-evidence used to evaluate the actual or potential hazards associated with the indicator chemicals at the WRR Site.

Provided in Appendix K are summaries of the main toxicological properties and adverse health effects of each indicator chemical. The summaries are not meant to be a comprehensive overview of toxicological characteristics. Detailed profiles can be found in the toxicological literature.

6.3.1 Dose Response Relationship.

Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects. The available toxicological information indicates that many of the indicator chemicals possess both non-carcinogenic and carcinogenic toxicity in humans and/or in experimental animals. Because the basic biological assumptions underlying how chemicals produce cancer vs. how they produce other toxicities differ, the U.S. EPA has developed separate dose-response protocols for cancer risk estimation and for non-cancer risk estimation.

Toxic effects considered in the dose response relationship include:

- o Non-carcinogenic Health Effects - Non-carcinogenic health effects may occur upon exposure to a certain dose of a chemical. Toxicological endpoints, routes of exposure, and doses in humans and/or animal studies are considered, as appropriate. Non-carcinogenic health effects are viewed as possessing thresholds; i.e., doses which must be exceeded before biological harm is produced. Therefore a health risk is believed to exist only if established threshold doses are exceeded.
- o The SPHEM provides values for evaluating a chemical's non-carcinogenic toxicity in the following manner:
 - RFDs - Reference Dose for Subchronic Exposure
 - RFD - Reference Dose for Chronic Exposure
- o Carcinogenic Health Effects - Exposure to a carcinogen could potentially be associated with adverse health implications (cancer). Routes of exposure and doses in humans and/or animal studies are provided in the toxicity profiles. Weight of evidence for a compound's carcinogenicity considers EPA's and the International Agency for Research on Cancer's carcinogen classification schemes, and the carcinogen reviews by the National Toxicology Program (NTP) and the National Academy of Science (NAS). For those compounds judged to be potentially carcinogenic in humans, models are developed to predict cancer risk at low exposure dose levels. Two models are primarily used by the U.S. EPA: the linear

extrapolation model and the linearized multi-stage extrapolation model. Both models produce a straight line relationship at low dose levels, the slope of which is termed the cancer potency factor (PF).

- o RFDs, RFD and PF values come from EPA's verified reference doses, evaluations by EPA's Carcinogen Assessment Group (CAG), and Health Effects Assessment (HEA) documents. The SPHEM encourages use of these values, thus, they have been appropriately applied. Available (published) reference doses and potency factors for the indicator chemicals are listed in Table 34.

6.3.1.1 Non-carcinogens.

The toxicity values for non-carcinogens are described by an RFDs or an RFD exposure value. The values represent an estimate of an exposure level not anticipated to cause an adverse effect over a lifetime (chronic) exposure or as a result of a shorter period of exposure (subchronic, 10% of an individual's lifetime can be used as a reference for this exposure period). Use of this information allows for characterization of long-term and short-term health risks.

RFDs and RFD values are derived from toxicity studies (usually animal studies or human epidemiological studies, if available) on the relationship between human intake and non-carcinogenic toxic effects (U.S. EPA, 1986). They are designed to be protective of sensitive populations and are route specific.

RFDs values are based on subchronic (10-90 day) animal toxicity studies (some may be derived from human exposure data). The RFDs is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). It is generally derived from a no-observed (adverse) effect-level (NOAEL or NOEL) or a lowest-observed-adverse-effect-level (LOAEL). Uncertainty factors are applied to NOAELS, to arrive at the RFDs value. The uncertainty factors include a factor of 10 for extrapolation of animal studies for human effects. An additional factor of 10 is applied to account for intraspecies variability.

A similar process applies to RFD values. An exception is that RFD values are based on chronic (long-term) animal studies. An additional safety factor of 10 is applied if subchronic studies are used in place of chronic studies.

The RFDs values provided in SPHEM are route specific. Values for inhalation and oral routes of exposure are provided in SPHEM, however, several of these values are not available for the indicator chemicals. Also, there are no values available for assessment of the dermal route. Therefore, several RFDs values require development. The U.S. EPA does not prescribe to these derived values although in the SPHEM, consideration of chemicals that do not have toxicity values (RFD or RFDs) is left to professional judgment for interpreting hazards at a particular site. Because subchronic exposure scenarios have been modelled for the WRR Site, RFDs values are necessary to quantitatively evaluate and interpret the hazards posed by each indicator chemical. RFDs values provided by U.S. EPA for use in this assessment are limited, therefore, to provide a method for evaluating indicator chemicals without published values, several RFDs values have been derived and used. RFDs values derived for the indicator chemicals are provided below, where applicable, and summarized in Table 34.

Vinyl chloride An RFDs for vinyl chloride does not currently exist. However, an oral RFDs value of 0.001 mg/kg/d is recommended. The recommended value is one-tenth of the American Conference of Governmental Industrial Hygienists (ACGIH) recommended workplace standard. The dermal and inhalation RFDs values are assumed to be equivalent to the oral RFDs.

1,2-Dichloroethylene (1,2-DCE) An oral RFDs for 1,2-dichloroethylene of 0.079 mg/kg/d was derived for this assessment. This recommended dose is one-tenth of the ACGIH recommended workplace standard. This value is also applied to the dermal and inhalation exposure pathways. The RFD (chronic) value was assumed to be one-tenth of the RFDs derived value.

Trichloroethylene (TCE) A recommended oral RFDs for trichloroethylene of 0.027 mg/kg/d was calculated for this assessment. This recommended reference dose is also used for dermal and inhalation exposure routes. This value is one-tenth the ACGIH recommended workplace standard.

bis(2-ethylhexyl)phthalate (DEHP) This phthalate has a chronic reference dose of 0.02 mg/kg/d (SPHEM). The RFDs via the oral, dermal and inhalation routes was assumed to be the same.

Polynuclear aromatic hydrocarbons (PAH) An RFDs for PAHs could not be determined for this assessment. There is insufficient information in the scientific literature to estimate or recommend a subchronic reference dose for PAHs.

Polychlorinated Biphenyls (PCB) PCB does not have an available RFDs. To derive the RFDs value to be applied to the oral, dermal and inhalation exposure routes, a safety factor of 100 (0.01) was applied to the lowest dose reported in the literature that produces a subchronic health effect (chloracne; Meigs, et al., 1954; Kuratsune, et al., 1972). The reported dose is 0.03 mg/kg/d; the derived RFDs value recommended for PCB is 0.0003 mg/kg/d.

Cadmium Cadmium has an available oral RFD of 5×10^{-4} mg/kg/d. This value is applied to the oral, dermal and inhalation subchronic exposure routes as an RFDs value.

Arsenic As with cadmium, there is no RFDs value, however, there is an RFD value of 0.001 mg/kg/d. This value was used in this assessment to represent oral, dermal and inhalation RFDs values.

6.3.1.2 Carcinogens.

The Carcinogenic Potency Factor (PF) is applicable for estimating the lifetime probability (assumed 70-year lifetime) of human receptors contracting cancer as a result of exposure to known or suspected carcinogens. This index is generally reported in units of acceptable dose (mg) per unit body weight (kg) per unit time (day) and is derived through an assumed low-dosage linear relationship and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit.

Potency factors are available in SPHEM to evaluate the carcinogenic indicator chemicals and RFD values are available for evaluation of chronic effects associated with non-carcinogens.

6.4 Exposure Assessment.

The aim of the exposure assessment is to arrive at an estimation of the magnitude of contaminant intake by exposed populations. This estimation integrates information on pathways of contaminant migration within the environment, concentrations of contaminants at points of contact with receptors, estimations of the degree of receptor contact with the contaminated media, and factors which address the kinetics of contaminant entry into the body (e.g., dermal permeability coefficients). This

assessment is performed using assumptions of population activities based on current land use conditions at the site and assumptions which intend to predict possible future conditions at the site.

6.4.1 Exposure Pathway Analysis.

A complete exposure pathway must contain the following elements: 1) the presence of a contaminated environmental medium, or, for a potential pathway, a mechanism of contaminant migration from a source; 2) a point at which the contaminated medium may contact with receptors; and 3) the presence of human or environmental receptors exposed to the contamination. Under current site conditions, only complete exposure pathways will be evaluated for their contribution to overall health risk. Assumptions of site conditions will define complete pathways to be evaluated for future risk. Figure 39 illustrates potential exposure pathways for current and future conditions at the WRR Site.

6.4.2 Sources of Contamination.

With the exception of the "discolored area", removal activities which have occurred at the site (see Section 1.2.3) have removed the majority of contaminated materials in the known discrete sources of contamination at the WRR Site. However, surface and subsurface soils have become contaminated as a result of the disposal activities that took place at the WRR Site. In some cases, wastes were dumped directly onto the ground. In addition, barrels containing wastes, located on the ground surface or buried, had corroded and leaked materials to surrounding soils. Therefore, contaminated soils can be considered a source of contamination for individuals and wildlife which come in direct contact with them. These soils can also be considered a source of future environmental contamination as chemicals migrate from them (e.g., leaching to groundwater).

6.4.3 Potential Exposure Pathways Under Current Site Conditions.

Based on the contaminated media identified at the site and current land use activities at the site, a number of potential pathways for contaminant exposure exist (Table 35). Figure 40 illustrates these potential pathways. The following will discuss the potential exposure pathways for a given medium, their likely exposure potential and relevance to site risk evaluation.

6.4.3.1 Groundwater.

The potential for exposure to hazardous chemicals through groundwater exists for residents of Columbia City who use municipal water and residents who use water from private wells, should the contaminated aquifer impact these wells. Results from the recent round of groundwater samples collected from the Municipal Well #8 and from the nearest private wells indicated that chemical contamination had not impacted these wells. Since this potential exposure pathway is not complete, it will not be considered to contribute to health risk under current site conditions. Potential for contaminated groundwater impact of potable water sources in the future is discussed below.

6.4.3.2 Surface Soils.

Analysis of surface soil samples from the site show areas of contamination throughout the property, however, the southeastern section of the site appears to contain the highest levels of contaminants. Surface soils on most areas of the site are covered with dense, grassy vegetation, shrubs and some trees. Three excavated areas, the "oil-decanting pit", the "sludge ravine", and the "discolored area" show bare soils with minimal vegetation. These three areas are enclosed by a chain-link fence. These measures, however, do not completely eliminate the possibility of trespassers entering the site and coming in contact with contaminated soils.

Exposure to contaminants from soils can result from direct contact and from contact with fugitive dusts generated as a result of wind erosion of bare soils. Routes in which contaminated soils can enter the body include absorption through the skin, inhalation of fugitive dusts and incidental ingestion of soil particles. Since the areas of exposed soils at the site are small, the magnitude of exposure to contaminants by fugitive dusts is likely insignificant and not considered in the estimation of risks.

Although the frequency and extent of trespass onto the site cannot be determined with certainty, health risk resulting from direct contact with soils will be evaluated for trespassers, using assumptions about their frequency and duration of exposure.

Wildlife which inhabit the site may also be impacted by the contaminated soils. Although an ecological survey was not conducted, the site most likely supports small populations of birds, small mammals and possibly occasional deer. Wildlife populations would be exposed to the contaminants through direct contact and ingestion of contaminated soils. Since these wildlife populations would likely be small and difficult to estimate, this pathway will not be included in the assessment of total site risk.

6.4.3.3 Surface Water and Sediments.

Chemical contaminants were identified at low concentrations in surface water and sediment samples taken from the freshwater pond on-site and the Blue River adjacent to the site. Populations potentially impacted by these contaminated media would include trespassers and terrestrial and aquatic wildlife as a result of direct contact and/or incidental ingestion of these media. The potential for significant exposure to contaminants by trespassers is likely very low since the concentrations of chemicals detected in samples from the freshwater pond are low and the presence of steep banks adjacent to the Blue River would inhibit access of trespassers to surface water and sediment from the site. Contaminants were also identified in a surface water sample taken from the excavated oil decanting pond. Surface water from this area, however, was not considered a significant point of exposure since this area is only wet intermittently and is fenced.

The potential hazard to people potentially consuming contaminated fish populations at the site are likely small as the Blue River in the vicinity of the site does not support sport fishing.

6.4.3.4 Subsurface Soils.

Contaminated subsurface soils could become a point of exposure to remediation workers at the site through excavating activities. The potential hazard associated with this pathway is predicted to be very low and not considered in the estimation of site-related risk since these individuals would be wearing appropriate protective gear.

6.4.3.5 Air.

Potential exists for volatile contaminants identified in soils at the site to volatilize and present a point of inhalation exposure for on- and off-site populations. However, results of photoionization detection (HNU) analyses of air samples taken on-site were undetectable and do not support this possibility. Thus, this pathway is not complete and will not be considered in the estimation of site-related risk.

6.4.4 Assumptions of Future Site Conditions and Related Exposure Pathways.

To attempt to estimate risks to populations as a result of future events which could affect the migration of contaminants detected at the site, assumptions about natural and man-made changes which influence site conditions were made (Table 36). Given that these future site conditions are hypothetical, only scenarios which seemed most relevant to understanding potential site risk were considered (see Figure 41).

The following section describes potential changes in the existing exposure pathways which would occur as a result of future site assumptions as well as new exposure pathways predicted by the assumptions (Table 36). The likelihood of exposure by these pathways is also considered.

6.4.4.1 Migration of Contaminated Groundwater Plume to Municipal Production Well.

Results of the site hydrogeologic investigation indicated that although the direction and rate of groundwater flow within the upper aquifer is little affected by the pumping of Municipal Production Well #8, the direction of groundwater flow in the lower aquifer can be reversed toward Well #8 when it is pumping. Results of pump testing with Well #8 also revealed the presence of some hydraulic interaction between the upper and lower aquifer. (Refer to Section 3 for details of the hydrogeologic investigation). Given these conditions, increased use of Municipal Well #8 may induce contaminant migration from the upper aquifer into the lower aquifer and to this well, impacting users of municipal water. Although not likely, this scenario may be possible were an increase in demand for water placed on the municipal system (e.g., presence of an industry utilizing large quantities of process water). It is also conceivable that malfunctions in Production Wells #6 and #7 would result in relying solely on Well #8 to supply municipal water demand. Thus, as a worst case scenario, it was assumed that Well #8 is supplying municipal water, drawing in part of a contaminated groundwater plume from the upper aquifer. Assumptions about the proportion of contaminants identified in the upper aquifer that would likely impact Well #8 were made and a dilution factor of 200 was used to estimate municipal water contaminant concentrations (Section 3).

This exposure pathway was evaluated assuming water is used by Columbia City residents for domestic purposes. Routes of contaminant exposure to individuals using water for domestic purposes include: ingestion from drinking and cooking, and dermal absorption and inhalation of volatile chemicals while bathing.

6.4.4.2 Migration of Contaminated Groundwater Plume to Private Residential Well.

Remedial investigation activities included analysis of groundwater samples from monitoring wells located on WRR Site property. In addition, groundwater samples from Municipal Production Well #8, located approximately 100 feet to the north of the site and several groundwater samples from private

residential wells located approximately 1/2 mile south of the site were analyzed. Contaminated groundwater is currently not impacting off-site wells. Based on concentrations of contaminants identified in monitoring wells located on the perimeter of the WRR Site, downgradient of natural flow directions, a significant attenuation of contaminant levels may occur. Thus, the potential for contaminant impact to existing private wells may be low.

Land to the north and west of the site has been developed for either industrial or residential purposes. Water used by individuals located in these directions would be met by the Columbia City water utility. Land adjacent to the site to the east and south is at present not developed. Information obtained from the Columbia City Planners indicated that this property is currently zoned industrial, and will become part of an industrial park. Thus, the likelihood of residential development in these areas with installation of a private well is remote.

Groundwater flow conditions off-site to the east and southeast, beyond the Blue River have not been characterized. The potential health risks associated with this exposure pathway were assessed by assuming a proportion of the groundwater contaminants (1/30) impact private wells (refer to Section 3.6 for details on the derivation of the dilution factor). As above, contaminant intakes were calculated for ingestion, dermal absorption and inhalation routes of exposure.

6.4.4.3 Site Development for Industrial Purpose.

Columbia City zoning restrictions currently in place limit potential development of the WRR Site to industrial purposes. To assess potential health risks which may result from exposure to site contamination, it was assumed that industrial development would occur in the future.

The potential for residential development of the site was not considered for the calculation of potential health risks because the likelihood of this occurrence was considered to be very low. In addition to being zoned for industrial use, several other factors limit the likelihood of residential development:

- o the presence of nearby industry, would make residential development unlikely,
- o the close proximity of the city landfill to the site would make residential development undesirable, and

- o residential development of the site would be undesirable because the site is located in the Blue River floodplain with the water table approximately 10 feet below the surface.

Development of the site for either purpose (residential or industrial) would not be expected to subject the eventual occupants of site residences or facilities to site contamination since this area would be serviced by municipal water and site development would require extensive filling. Thus, exposure to contaminated groundwater and soils would likely not occur.

The most significant opportunity for exposure to contaminants, assuming future industrial development, would be for construction workers exposed during construction of the hypothetical industry. Thus, potential health risks to construction workers exposed by direct contact with contaminated soils were estimated.

6.4.4.4 Contamination of the Blue River by Site Runoff.

In the event of flooding (the southeast part of the WRR Site is located in the Blue River flood plain), contaminated soils could be introduced into the Blue River via surface runoff. Populations potentially impacted could include: downstream human populations who use Blue River for recreational activities (swimming), aquatic organisms in the Blue River and populations (human and wildlife) which consume potentially contaminated aquatic organisms. However, the Blue River is not conducive to recreational activities, such as swimming. Also, the river does not support game fish populations adjacent to the site and is therefore not likely a source of fish for human consumption. Thus, these potential exposure pathways were not considered in the evaluation of future site risk since the potential for significant exposure is likely very low.

6.4.5 Exposure Pathways of Greatest Concern at the WRR Site.

Risk to human health will be quantitatively estimated for the following exposure pathways using current site conditions and assumptions of future site conditions:

Current site conditions

- o Exposure of trespassers to contaminated soils on-site.

Future site conditions

- o Exposure of Columbia City residents to contaminated water from the municipal distribution system.
- o Exposure of residents to contaminated water from private wells.
- o Exposure of construction workers to contaminated soils while constructing a hypothetical industry on-site.

6.4.5.1 Receptors Impacted by Contamination.

Activity patterns and assumptions about media contact may vary significantly with the age of the individual. For this reason, contaminant intake doses and ultimately health risks will be estimated for subsets of the population as follows: Toddlers, 0-5 years; Adolescents, 6-20 years; and Adults, 21-70 years.

Trespassers would most likely be comprised of adolescents. Only adults will be considered to comprise construction workers which would be potentially be exposed if the site is developed in the future. Risk associated with exposure to contaminated groundwater from the municipal distribution system will be evaluated for all age categories.

6.4.6 Estimation of the Extent of Contaminant Exposure.

In this section a quantitative estimate of the dose incurred by a receptor is made. Medium-specific concentrations of indicator contaminants at points of receptor contact (exposure point concentrations) are combined with estimates of media intake rates for receptors in each exposure pathway to arrive at the receptor's dose. For each exposure pathway, multiple routes of contaminant entry into the body exist. Table 37 summarizes the contaminant intake routes for receptors within each exposure pathway considered for risk characterization.

6.4.6.1 Exposure Point Concentrations.

Values for chemical contaminants within each medium were obtained directly from the analytical data. Since specific points of contaminant exposure (e.g., exact locations of trespasser contact with soil) or the specific pattern of contaminant migration off-site (e.g., specific chemicals migrating to the municipal well) cannot be determined with certainty at this site, site-wide geometric means were used to characterize the contaminated media. This procedure would, however, underestimate the contaminant dose incurred by

a receptor should it encounter localized areas of high contaminant concentrations which were characteristic of the WRR Site. For this reason site maximum concentrations, in addition to geometric averages, were used for dose calculations. It is to be understood that implicit in risks calculated from maximum concentrations or average concentrations from localized contaminants, it is assumed that the receptor contacts only areas with these contaminant concentrations. Thus, these calculated risks represent a worst-case situation and the actual risk is directly related to the likelihood of the assumptions occurring.

Table 38 summarizes the maximum and average exposure point concentrations of each indicator chemical used for calculation of receptor doses within each exposure pathway considered for subsequent risk characterization.

6.4.6.2 Media Intake Rates.

Table 39 summarizes age-specific assumed media intake rates for ingestion and inhalation exposures and critical exposure factors used in the estimation of intake rates for the dermal route of exposure. The rates and factors selected are not necessarily representative of all receptors and can be influenced by multiple factors such as lifestyle, hygiene habits, age, gender, health and nutritional status and the socioeconomic level. Choices made for these parameters were intended to represent conservative estimates of typical or expected intake values. These values were obtained from the following sources: U.S. EPA, 1985, 1986 and 1987. In addition, assumptions about the frequency of contact with soils were made for trespassers and future construction workers at the site (Table 40).

6.4.6.3 Estimation of Contaminant Intakes.

The following will describe the calculations used to estimate contaminant intake doses for each intake route. Associated with the methods used to estimate intake doses via all routes are assumptions and limitations. The most significant limitations with each method are identified. Refer to Tables 39 and 40 for assumptions of media intake rates, frequency of exposure events and exposure factors. The intake doses are presented in Tables 41-43.

6.4.6.3.1 Groundwater - Ingestion.

Potential doses of contaminants from ingestion of groundwater can be estimated using the following relationship:

$$\text{Ingested dose} = \frac{\left(\frac{\text{contaminant}}{\text{concentration}} \frac{\text{mg}}{\text{l}} \right) \left(\frac{\text{consumption}}{\text{rate}} \frac{\text{l}}{\text{d}} \right)}{(\text{body weight, kg})}$$

(mg/kg/day)

This relationship assumes 100% of all ingested compounds are absorbed from the gastrointestinal tract.

6.4.6.3.2 Groundwater - Dermal Absorption.

Dermal absorption can be the most important route of exposure for certain volatile organic compounds present in water. Dermal exposure can be estimated using the following relationship:

$$\text{Dermal Dose} = \frac{(t_e)(AV)(C)(PC)(F)(0.001 \text{ l/cm}^3)^a (0.5)^b}{(\text{body weight, kg})}$$

(mg/kg/d)

where: t_e = duration of exposure, 0.33 hour/event
 AV = skin surface area available for contact with water (Table 39)
 C = concentration of contaminant, mg/l
 PC = dermal permeability constant for contaminant
 F = frequency of the event, 1 event/day
 a = conversion factor
 b = Used for volatile chemicals only. Percentage of chemical which remains in water (not volatilized).

The indicator compounds selected most likely vary greatly in their ability to permeate the skin. However, values for permeability constants for these compounds do not currently exist in the scientific literature. Therefore, in accordance with U.S. EPA guidelines, it is assumed that the contaminants are carried through the skin as a solute in water which is absorbed (rather than being preferentially absorbed independently of water), and that the contaminant concentration in the water being absorbed is equal to the ambient concentration. For this reason, the permeability constant of water (8.00×10^{-4} cm/hr) will be assumed to be the factor for all indicator chemicals which control the rate of absorption.

When doses of volatile chemicals were calculated it was assumed that 50% of the chemical volatilizes and 50% remains in solution.

6.4.6.3.3 Groundwater - Inhalation.

The following relationship is used to estimate the dose of volatile chemicals incurred with bathing or showering.

$$\text{Inhalation dose} = \frac{t_e(IR)(C)(F)\left(\frac{190 \text{ l}}{12 \text{ m}^3}\right)^a (0.5)^b}{(\text{body weight, kg})}$$

(mg/kg/day)

where: t_e = duration of response, 0.33 hr/event
IR = average inhalation rate, assume light activity while bathing (Table 39)
C = concentration of contaminant, mg/l
F = frequency of exposure, 1 event/day
a = assume 190 l of water used per event and dimension of bathroom are 12m³
b = volatilization factor; assume 50% of chemical volatilizes

6.4.6.3.4 Soils - Dermal Absorption.

The doses of indicator chemicals were estimated for dermal exposure using the following equation:

$$\text{Dermal dose} = \frac{(C_i)(AV)(SA)(F)(B)}{(\text{mg/kg/day}) (\text{body weight, kg})}$$

where: C_i = weight fraction of chemical substance in soil (unitless)
AV = skin surface area available for contact with soil, cm² (Table 39)
SA = soil adherence to skin, mg/cm² (Table 39)
F = frequency of exposure events, events/day. This is assumed to be 1.
B = dermal bioavailability factor

This method assumes all of the contaminant adsorbed to the soil particle is available for absorption through the skin. In reality, only a fraction of the chemical would be available for absorption; the remainder being bound to the soil particle. Differences in the dermal permeabilities among the indicator chemicals were roughly accounted for by estimating the fraction of compound absorbed (dermal bioavailability factor) as follows: volatile organic chemicals, semi-volatile chemicals and cyanide, 100%; and all metals, 1%.

6.4.6.3.5 Soils - Ingestion.

The dose of a soil-bound contaminant ingested by an individual can be estimated using the same relationship described for ingestion of water-borne contaminants, above. It is assumed that both adults and adolescents ingest 0.1g soil/day.

6.4.6.4 Calculation of Subchronic and Chronic Intake Doses.

Doses of contaminants incurred by individuals were initially calculated as event-based daily intakes (i.e., dose in mg/kg/day for the sum of the exposure events occurring per day; e.g., for soil exposure by trespassers

assume 1 event per day). These doses were then used to calculate daily intakes for both subchronic and chronic exposures. Thus, the event-based doses were normalized over the appropriate exposure period. For example, the subchronic exposure periods for trespassers was 5 years, occurring once per week for 8 months of the year. Long-term, chronic risks were estimated only for groundwater exposures since exposure to soils for trespassers and construction workers was defined to be subchronic, 5 years and 18 months, respectively.

In addition, chronic lifetime risks were calculated by incorporating assumptions about the receptors stage of life. It was assumed that the life of the receptor is composed of three stages: a 5-year toddler stage, a 15-year adolescent stage, and a 50-year adult stage. Doses were initially quantified for each of these age groups. A time-weighted averaging equation was then used to calculate the lifetime average daily dose incurred by receptors in each exposure pathway:

$$\bar{D} = \sum_{i=1}^3 \frac{(\text{Daily dose for } i)(\text{Number of Years in } i)}{70 \text{ Years}}$$

For example, calculation of lifetime doses for exposure to contaminated water assumed an individual was exposed from the time of birth to the age of 70. Lifetime doses for adolescents assumed 15 years as an adolescent plus 50 years as an adult.

Daily doses for subchronic and chronic exposure conditions are presented in Tables 41-43.

6.5 Risk Characterization.

In this section of the report, the potential risks to public health associated with chemical release from the WRR Site are presented. This section has the following subsections:

- o Procedures Used to Calculate Health Risk
- o Public Health Risk Evaluation
- o Comparison of Standards, Criteria and Guidelines
- o Environmental Assessment
- o Uncertainties in the Health Risk Evaluation

6.5.1 Procedures Used to Calculate Health Risk.

Health risks in this assessment were evaluated for non-carcinogenic and carcinogenic effects of the indicator chemicals.

6.5.1.1 Non-carcinogens.

Estimating the risk due to a chemical eliciting a non-carcinogenic effect is accomplished by calculating a hazard index. The hazard index is obtained by dividing the estimated site specific subchronic or chronic exposure dose by the available reference dose for that chemical (RFD or RFDs values). Refer to Section 6.3.2.1 for explanation of these reference doses.

$$\text{Hazard Index} = \frac{\text{Estimated Daily Dose (mg/kg/d)}}{\text{Reference Dose (mg/kg/d)}}$$

If the HI exceeds unity, there is a potential health risk associated with exposure to the particular chemical evaluated (U.S. EPA, 1986). The HI is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the transition from acceptable to unacceptable levels.

6.5.1.2 Carcinogens.

Carcinogenic risks can be estimated by multiplying the carcinogenic potency factor for a compound by the estimate of the individual intakes (doses) of that chemical.

$$\text{Risk} = (q^*)(\text{dose})$$

Where: q^* = Carcinogenic potency factor (slope of the dose response curve, Section 6.3.2.2) in $(\text{mg/kg/d})^{-1}$

dose = Amount of a contaminant absorbed by a receptor in (mg/kg/day)

The resulting number (risk) is a unitless expression of an individual's likelihood of developing cancer as a result of exposure to the carcinogenic indicator chemicals. This likelihood is in addition the risks incurred by everyday activities. The risk (e.g., 1×10^{-6} or a 1 in 1,000,000 chance) can also be applied to a given population to determine the number of excess cases of cancer that could be expected to result from exposure (e.g., 1×10^{-6} is one additional case of cancer in 1,000,000 exposed persons). Total risks for exposure to multiple compounds can be presented as the summation of the risks for individual chemical intakes, assuming that there

are not antagonistic/synergistic effects between chemicals and that all chemicals produce the same result (cancer). Cancer risks from various exposure routes are also additive, if the exposed populations are the same.

Carcinogenic risks are calculated using a number of assumptions, therefore many uncertainties are introduced into the values. Factors limiting the extent to which the human and environmental health risks can be characterized are primarily associated with the estimation of toxicity and include various uncertainties in the toxicological data base. Extrapolation of non-threshold (carcinogenic) effects from high to low dose, variance in endpoints used for determination of potential health effects, extrapolation of the results of animal studies to human receptors, varying sensitivity between individuals, and other uncertainties make definite characterization of health risks infeasible.

6.5.2 Public Health Risk Evaluation.

Chronic (lifetime exposure) and subchronic (10% of a lifetime, used as a reference for this exposure period) hazard indices as well as cancer risks are summarized by the exposure pathways for each indicator chemical in Tables 44-46. From these values, only compounds with hazard indices >0.01 and cancer risks $>1 \times 10^{-7}$ are presented in Tables 47-49. Risks were calculated based on site mean and maximum contaminant concentrations identified at the site to represent "most likely" and "worst case" exposure conditions, respectively. These values are organized according to exposure pathways and a total risk for each pathway is calculated by summing risks from individual chemicals (Tables 47-49).

6.5.2.1 Current Site Conditions.

Exposure of trespassers (assumed to be adolescents) to contaminated surface soils was considered to be the most realistic scenario for exposure to contaminants identified at the WRR Site under current site conditions.

Under the assumptions made (adolescents trespassing once/week, 8 months/year for 5 years), potential non-carcinogenic hazards related to subchronic exposure and potential cancer risks, were identified. Since it was assumed that trespassers would be exposed on a subchronic basis, calculation of chronic risks from non-carcinogenic contaminant exposure was not applicable. Risks of non-carcinogenic effects which would be expected from subchronic exposure to indicator chemicals ($HI >0.01$) were, in general, observed only for maximum concentrations of the chemicals indicating the localized nature of site contamination. A HI greater than unity was calculated for exposure

via the dermal absorption route to the sum of maximum chemical concentrations. Exposure to the maximum concentration of cyanide contributed the majority of this hazard. Other chemicals contributing to the hazard included bis(2-ethylhexyl)phthalate (DEHP), PCBs, cadmium, chromium and zinc (Table 47). Incidental ingestion of soil by trespassers showed a pathway hazard of 0.32, resulting from exposure to only maximum concentrations of cadmium, chromium, zinc and cyanide.

The potential carcinogenic risk to trespassers was related primarily to PAHs, PCBs and arsenic via the dermal absorption and ingestion routes, with trichloroethene and DEHP contributing a lesser risk via the dermal absorption route (Table 49). Pathway risk for the sum of the indicator chemicals for trespassers was calculated to be approximately 100 times greater for the dermal absorption route than the incidental ingestion route. Calculated cancer risks from dermal exposure to PAHs (ca. $2.0\text{E}-02$) and PCBs (ca. $5.0\text{E}-04$) are conservative estimates resulting from the localized occurrence of these compounds at the site.

6.5.2.2 Future Site Conditions.

The potential health risks associated with using contaminated groundwater were addressed for users of municipal water and water from private wells. Calculated risks for the two receptor populations are qualitatively similar, but differ in magnitude as a result of different factors used to estimate contaminant dilution. Thus, risk to private well water users was estimated to be approximately seven times greater than that for municipal water users. Domestic groundwater use includes three predominant routes of contaminant intake: ingestion from drinking and cooking; dermal absorption while bathing; and inhalation of volatile chemicals while showering. Of these intake routes, dermal absorption appeared least significant, showing no non-carcinogenic hazard indices greater than 0.01 and only a relatively low cancer risk (ca. $2.0\text{E}-05$) to maximum concentrations of vinyl chloride for private well users. Cancer risk to average concentrations of vinyl chloride for private well water users were approximately $2.0\text{E}-07$ via dermal absorption.

Risks to non-carcinogenic health effects resulting from subchronic exposures were related predominantly to the volatile chlorinated compounds, vinyl chloride (VC), 1,2-dichloroethene (DCE) and trichloroethene (TCE) via the ingestion and inhalation routes. Toluene, cadmium and arsenic produced low HIs (<0.1) for private well users. Of the chlorinated volatile compounds, maximum concentrations of vinyl chloride contributed most significantly to the health risk (Table 47).

Chronic exposure to contaminants (non-carcinogens) identified in groundwater resulted in HIs greater than unity for DCE via the ingestion and inhalation route for both municipal water and private well water consumers. Toluene and cadmium exposure resulted in low chrome HIs (<0.015) for private well water users.

Calculated potential risk of cancer was greatest for exposure from VC, ($1.5 \text{ E-}02$, maximum concentrations; $1.7 \text{ E-}04$, average concentrations; for private well water users, ingestion route) via all routes of groundwater contaminant exposure (Table 49). The maximum concentration of VC was 100 times greater than the average concentration, resulting in correspondingly higher risks for exposure to the maximum concentration. TCE, DEHP and arsenic also contributed to cancer risk via the groundwater ingestion route.

An additional potential pathway evaluated under future site conditions was exposure of construction workers to contaminated soils. Adult workers were assumed to be exposed to contaminants 5 days per week for 18 months. Hazard indices greater than 0.01 for toxic effects consistent with subchronic exposure were identified for DCE, TCE, DEHP, PCBs, cadmium, arsenic and cyanide via the dermal absorption and incidental ingestion routes. The HI for the combination of contaminants was 1.6 (maximum concentrations) and 0.51 (average concentrations) for the dermal absorption route. DEHP and PCBs contributed approximately equally (ca. 0.45) to the maximum value. Incidental ingestion produced a total HI of 0.3 for the maximum concentrations of metals. As for site trespassers, the exposure period was assumed to be subchronic and therefore, no chronic hazard indices were calculated.

Cancer risks greater than 1×10^{-7} were identified for the dermal absorption and incidental ingestion route. Contaminants contributing to the risk included VC, TCE, DEHP, PAHs, PCBs and arsenic. Of these contaminants, PAHs contributed the majority of the pathway cancer risk (PAH, ca. $5 \text{ E-}02$, dermal absorption; ca. $8 \text{ E-}04$, ingestion). As above, the localized occurrence of PAHs results in a conservative risk value.

6.5.2.3 Summary of Potential Health Risks.

Under current and future site conditions, potential health risks to persons contacting soils (current trespassers and future construction workers) are related primarily to PCBs, PAHs, arsenic and cyanide. Of these health threats, risks of non-carcinogenic effects are generally low with only

cyanide resulting in an HI greater than unity for trespassers, and this only for the maximum detected concentration. All other HI values calculated for other compounds were less than 0.5. Although cancer risk exceeds 1 in 100 for trespassers and construction workers via the dermal absorption route, the risk value is nearly entirely related to PAH exposure which would occur at few areas at the site. In the absence of remedial actions, the likelihood of individuals contacting these localized contaminants as assumed for the calculation of risk values, would be lower, thus reducing risk values. Additional non-carcinogenic and carcinogenic risks were identified for TCE, DEHP, cadmium, chromium, arsenic, zinc and cyanide via soil contact. However, these risks were, in general, identified only for maximum concentrations and not site averages. Therefore, actual risk associated with these compounds would probably be lower due to the localization of the contaminants.

Potential future risks to individuals drinking contaminated water are related to the chlorinated ethene compounds, DEHP and arsenic. The majority of non-carcinogenic health hazards were related to vinyl chloride (subchronic effects) and DCE (chronic effects) exposure. Exposure to vinyl chloride, TCE, DEHP and arsenic resulted in cancer risks greater than 1 in 100. In that conservative assumptions were made for groundwater risk calculations, actual risks are likely much lower. For example, hazard to contaminated municipal groundwater assumes that Municipal Well #8 is the sole supplier of municipal water. For cancer risk, this situation would have to occur for an individual over 70 years.

As a result of the intention of the risk analysis, which is to predict scenarios of greatest hazard, actual risks to individuals exposed to contaminants originating from the WRR Site are likely to be lower.

6.5.3 Comparison of Standards, Criteria and Guidelines.

Tables 50 and 53 contain Safe Drinking Water Act Maximum Contaminant Levels (MCL), Clean Water Act Ambient Water Quality Criteria (AWQC) for protection of human health and aquatic life and Indiana Water Quality Criteria (IWQC - applicable to all waters of the state). The following paragraphs provide brief descriptions of these criteria and a discussion of their comparison to on-site indicator contaminant concentrations in groundwater and surface water, as appropriate.

6.5.3.1 Maximum Contaminant Level (MCL).

The MCL is an enforceable standard designed to determine safe levels of a given contaminant in the public drinking water supply. The MCL as defined under the Safe Drinking Water Act is the allowable lifetime (70 yr) exposure (2 l/d) to a given contaminant to an average adult (70 kg) not be exceeded without risk to health. Factors involved in its determination include gastrointestinal absorption, a safety factor to protect potentially sensitive populations and the economic and technical feasibility of treating raw water to achieve these levels.

Maximum Contaminant Level Goals (MCLGs) are the non-enforceable health guidelines for a contaminant level in drinking water which would cause no known or potential adverse effect. MCLGs, which are always less than or equal to MCLs, consider only health-based criteria.

Below are chemicals found to exceed MCLs at some monitoring well locations.

Vinyl Chloride Seven Phase I monitoring well samples exceeded the vinyl chloride MCL of 2 ug/L (MW-1S, MW-3S, MW-4S, MW-10S, MW-11S, MW-83A(S), MW-83A(D)) and eleven Phase II monitoring well samples exceeded the MCL (MW-1S, MW-3S, MW-4S, MW-8S, MW-9S, MW-10S, MW-11S, MW-12S, MW-14S, MW-83A(S), MW-83A(D)). See Table 50.

Trichloroethylene Trichloroethylene was found to exceed its respective MCL (5 ug/L) in one monitoring well sampled during Phase I (MW-9S) and the same monitoring well in Phase II sample data. See Table 50.

1,1-Dichloroethylene and Benzene Although these chemicals were not evaluated as indicators in the risk assessment, 1,1-dichloroethylene was found to exceed its MCL of 7 ug/L in three Phase II monitoring well samples (MW-3S, MW-9S, MW-10S) and benzene exceeded its MCL (5 ug/L) in one Phase II monitoring well sample (MW-10S). See Table 50.

Arsenic Arsenic was the only metal detected at one monitoring well location sampled during Phase I that exceeded its MCL of 50 ug/L (MW-83A(D)). See Table 51.

6.5.3.2 Ambient Water Quality Criteria (AWQC).

The AWQC, defined under the Clean Water Act, are non-enforceable guides which estimate ambient surface water concentrations that will not result in adverse human health effects. The estimates, which assume a lifetime (70 yr)

exposure to an average adult (70 kg), were calculated assuming two exposure pathways: drinking water (2 l/d) and aquatic organisms (6.5 g/d) or aquatic organisms alone. In the case of proven or suspect carcinogens, the estimates are calculated to represent incremental levels of cancer risk.

Characterization of potential threats to the environment can also be based on a comparison of chemical concentrations in surface water to AWQC guidelines for the protection of freshwater aquatic life.

Of the AWQC available for the chemical detected at the site, methylene chloride was the only organic contaminant in surface water found to exceed its respective AWQC value for the protection of humans. AWQC for the protection of aquatic life is discussed in the Environmental Assessment section.

Methylene chloride Surface water location SW-10 sampled during Phase I exceeded the methylene chloride AWQC of 0.19 ug/L for the protection of humans. However, the measured concentration of methylene chloride (a common lab contaminant) at SW-10 (6.0 ug/L) was only slightly above the CRQL (5 ug/L) and may be attributed to lab contamination. See Table 52.

6.5.3.3 Indiana Water Quality Criteria (IWQC) for Groundwater.

The Federal MCLs have been adopted by the State of Indiana as standards for drinking water. Exceedances of these criteria have therefore been presented previously.

6.5.4 Environmental Assessment.

This section discusses potential exposure and environmental effects of site-related contaminants on aquatic and terrestrial biota.

6.5.4.1 Potential Exposures.

6.5.4.1.1 Surface Soils.

Contaminated surface soils present direct contact exposures to terrestrial wildlife and may contaminate aquatic organisms in surface water through surface runoff. Once in the surface water, contaminants may settle out in sediment or dissolve in the liquid phase. Exposures to terrestrial wildlife or aquatic species via the above pathways may lead to accumulation of contaminants in animal tissue. However, the population of terrestrial and aquatic species and extent of biota contamination is not currently documented to allow for further evaluation of these potential exposure impacts due to contaminated surface soils.

6.5.4.1.2 Surface Water/Sediments.

Limited sampling occurred during the remedial investigation for surface water and sediment. The surface water analytical results do not suggest high levels of contamination nor high frequency of contaminant detection. Contaminants were detected in greater variety and frequency in sediments. Sediment contaminants include several volatiles and metals, and some semi-volatiles (phthalates) and PCBs.

Aquatic and terrestrial species are expected to be the receptors of most concern with regard to the surface water and sediment mediums. Biouptake of contaminants in surface water and sediment may result in potential injury to the animal and the possibility of bioconcentrating contaminants in the tissues of these organisms. There is also the possibility for biomagnification of contaminants in the food chain.

The extent of environmental hazards due to surface water and sediment contamination is unknown due to insufficient information.

6.5.4.2 Environmental Effects.

Dose-response relationships for environmental effects are limited to comparison with the Aquatic Water Quality Criteria (AWQC) for the protection of aquatic life. These criteria specify the concentration of a compound in surface water which, if not exceeded, should protect most aquatic life. These criteria derived from both plant and animal data and were developed to protect the types of organisms necessary to support healthy aquatic communities. AWQCs and IWQCs may not protect aquatic life under all conditions. Tables 28 and 52 list the AWQC available for chemicals detected at the WRR site. Eight surface water locations exceeded the AWQC for protection of aquatic life for copper (AWQC = 6.5 ug/L; see Table 28). Lead exceeded its AWQC for protection of aquatic life (AWQC = 1.3 ug/L) at three locations (see Table 28). All surface water locations in the river exceeded the AWQC for protection of aquatic life for total cyanide (AWQC = 5.2 ug/l), including upstream locations. Two on-site surface water locations also exceed background.

6.5.5 Uncertainty.

There are several areas of uncertainty in this assessment of public health risk at the WRR Site: quantification of exposure doses for each receptor population; extrapolation of high dose animal toxicological data to low dose human exposure health risks; and the use of indicator chemicals to represent total site risk.

With respect to uncertainties associated with quantification of exposure doses, assumed behavior patterns and chemical fate modeling contain inherent uncertainties. In assessing populations exposed for the WRR Site EA, information from local agencies and site investigators was used. Because it would be impossible to model specific behavior patterns of the individuals around this site, certain representative population behavioral assumptions had to be made (Tables 39 and 40). In general, these behavioral assumptions are conservative, leading to over-estimations of health risks for each receptor population. Some of the more conservative behavior assumptions in this assessment include:

- o Individuals residing near the WRR Site will live in the area for 70 years.
- o Adolescents who play (trespass) on the site come into contact with surface soils at the frequency described in the Exposure Assessment section.
- o The hypothesized future industrial development of the site exposes workers.
- o Contamination remains steady state and is dependant on data collected during the remedial investigation while ignoring current on-site remediation (e.g., removal of contaminated soils).

Several uncertainty factors may be associated with the use of data as a result of sample analyses and validation of the data. Data with estimated concentrations of compounds (data flagged with "J") were used in the assessment even though a certain amount of error may be associated with the estimated value, the result of which may be a value greater or less than the reported value.

Animal or human extrapolation of toxicological data, as well as high dose to low dose extrapolation, also contains considerable uncertainty. This uncertainty is inherent in the various RFDs, RFD and PF values used in this assessment. Because the current RFD and PF values reported by the U.S. EPA were used in this assessment, no further comment on the degree of uncertainty in each of these values will be mentioned here.

Published RFDs values were available for four of the twelve indicator chemicals for this site. Therefore, most of the RFDs values were derived. Because these reference doses are considered short-term exposure 'standards', fractions of OSHA/NIOSH workplace standards were used to calculate RFDs values.

The magnitude of the uncertainty associated with the use of indicator chemicals to evaluate the 'total risk' of this site is largely dependent upon the selection process for the surrogate compounds. In an earlier section of this chapter is the documented procedure used for this selection process and the rationale for selecting these chemicals. Based on the guidance for indicator chemical selection (U.S. EPA, 1986), preliminary judgment indicated the majority of the risk to the public would be determined with the selection of the 12 indicator chemicals chosen.

Related to this last point is the assumption used to evaluate exposure to multiple carcinogens or multiple non-carcinogens. Both the possibility of synergism between chemicals and the possibility of no toxicological interaction between chemicals exist. The assumption of an additive effect between chemicals is an attempt to be conservative in this assessment, but leads to additional uncertainty with respect to specific chemical mixtures.

Because the final health risk estimates at this site are ascertained by comparing the estimated exposure doses (with their uncertainties) with appropriate reference doses (with their uncertainties), the final risk estimates should be viewed as approximate only. The health risks which have been calculated for this site should be used more on a relative (or comparison) basis by risk managers, rather than on an actual risk basis.

7.0 SUMMARY AND CONCLUSIONS

7.1 Geology and Hydrogeology.

The WRR Site is located on top of about 200 feet of unconsolidated glacial materials which overlie a shale and dolomite bedrock. Two separate aquifers have been identified beneath the site: an upper water table aquifer, and a lower confined aquifer. The upper aquifer is not known to be used as a water supply source, but the lower aquifer is the major water resource for Columbia City and the surrounding population. Columbia City's municipal well field is located north of the east half of the WRR Site, and one of two city wells is pumped approximately 8 to 10 hours per day.

Groundwater flow in the upper aquifer is from west to east. Surface water elevations indicate that the upper aquifer is recharged west of the site, and discharges to the Blue River along the east and south boundary of the site.

In the lower aquifer, the regional hydraulic gradient indicates that natural groundwater flow is from northwest to southeast, thus away from the city wells. When the city wells have not been used for 12 hours, the gradient is to the southeast. However, pumping the wells has the potential to reverse the horizontal hydraulic gradient in the lower aquifer. After 8 hours of pumping, the gradient beneath the site sloped from south to north, toward the well. The intensity of the regional gradient to the southeast is about 30 percent higher than the gradient beneath the site caused by pumping. In addition, at current water demands, the city wells are utilized less than 50 percent of the time. As a result, the average gradient is away from the city well field, with the regional gradient to the southeast. On a daily basis, groundwater migration beneath the site could be described as "taking three steps toward and four steps away" from the city well field.

Vertical hydraulic gradients were also observed to reverse between pumping and non-pumping phases. After 12 hours of recovery, an upward gradient was measured between the lower and the upper aquifer. After 8 hours of pumping, the vertical gradient was downward. The maximum downward gradient was two to four times greater than the maximum upward gradient, suggesting that there is a potential for leakage from the upper to the lower aquifer. Considering only the potential for downward migration, it is estimated that the maximum leakage volume from the upper to lower aquifer for the entire 30-acre WRR Site is on the order of 8 gallons per minute, during the time when the pump

in city well #8 is operating at 1500 gallons per minute. Therefore the dilution factor would be approximately 190:1 (1500/8).

7.2 Previous Cleanup Activities.

Altogether, previous removal actions have resulted in the removal of more than 13,000 tons of material from the WRR Site. With the exception of the "discolored area", these removal actions have removed the majority of contaminated material in the known disposal areas on the WRR site. At the "discolored area", the method of deposition seemed to be random spillage or leakage. Based on visual observations of the sidewalls of the excavation, residual waste exists primarily to the east and north of the "discolored area". There are also portions of the south and west side walls where contamination was observed. However, the remaining material would probably be better characterized as contaminated soil rather than waste. For purposes of the RI, these materials are referred to as Soil/Waste.

7.3 Nature and Extent of Contamination.

Sampling and chemical analysis of soils, waste, groundwater, surface water and sediments were performed at the WRR Site.

To assist in the evaluation of the extent and migration of hazardous substances at the site, similar types of compounds have been grouped together (Table 13). Chlorinated ethenes and to a lesser extent chlorinated ethanes and toluene were the predominant group of organic contaminants, occurring in all discrete media. In general, chlorinated ethene concentrations increased with depth. While low levels (<200 ug/kg) of chlorinated ethenes were detected in many areas of the site soil, the majority of the high levels were detected in a few areas of the site:

- o At the location of SB-7/MW9, elevated levels of volatile organics were detected during Phase I. Subsequent sampling in Phase II showed that the lateral and vertical extent of soil contamination in the area is probably limited. Elevated levels of volatile organics in groundwater were detected in the monitoring well at this location; however, its extent is also limited because groundwater in the area would move directly south and discharge to the river. Current testing of surface water samples downstream of this area do not detect any measurable impact on the river.

- o At the location of SB-40/MW14S, a similar situation occurs. Visual observations of surface soils in the area suggest that the lateral extent of this contamination may also be limited.
- o At the location of SB-2/MW7S, low levels of volatile organics (primarily tetrachloroethene and trichloroethene) were detected during Phase I. There is a limited area of contamination visible at the surface in this vicinity (there are also small patches of contamination visible at the surface in the vicinity of SB-19). Subsequent sampling in Phase II did not detect any significant sources of volatile organics in the subsoils. Groundwater in this area contains elevated levels of 1,2-dichloroethene. It is possible that the tetrachloroethene and trichloroethene detected in the subsoils are degrading to 1,2-dichloroethene. The lateral extent of groundwater contamination may be limited based on the detection of only vinyl chloride in MW4 located approximately 200 feet downgradient.
- o In several areas in the southeast area of the site, high levels of volatile organics were found. The wide scatter in total chlorinated ethene concentrations, even for borings located very close to each other (i.e. SB-36 and SB-24; SB-12 and SB-32) suggests random spillage as opposed to large scale dumping. In addition, the removal action at the site in 1988 caused the removal of a significant volume of soil from this area (Figure 4). In particular, contaminated soils from around MW3S, SB-12, and SB-36 have been removed. Groundwater immediately downgradient of the contaminated soils also contained elevated volatile organics (i.e. MW3S, MW10S). However, the data show that migration of volatile organics may be limited. For instance, when the results of total chlorinated ethenes from MW10S (61,500 ug/L) are compared to the results from MW11S (48 ug/L) located 250 feet downgradient, it is apparent that there may be either very little migration of contaminants with groundwater flow or very high attenuation or degradation occurring. It appears that some volatile organic compounds have migrated through groundwater to the sediment and surface water of the Blue River. The total chlorinated ethenes detected in surface water in the river were below the contract required quantitation limit (CRQL); total chlorinated ethenes detected in river sediments were near the CRQL at two locations (SD-4 and SD-5) and were detected at 1,230 ug/kg at SD-3.

Phthalates were frequently detected in all the discrete media; however, concentrations and distribution showed little correlation within and between media.

The distribution of PAHs at the Site was very limited and generally located in the upper 2 ft of the soils. The analytical results indicate at least two localized area of elevated PAH (SB-18 and SB-20) concentration on-site, but PAHs were not detected below a depth of six feet. No appreciable PAH concentrations were detected in groundwater, surface water or sediment samples.

Several inorganic parameters were detected in on-site soils at concentrations above what would be considered as the common range for "natural soils." Of the metals group magnesium, cadmium, copper, zinc and lead were detected at levels above these common ranges in subsurface soils. In general, the elevated levels of these compounds coincided with the areas described above for organic compounds. Metals were usually detected in highest concentrations in the top two feet of soils. However, one apparently isolated area of considerably high concentrations of these elements was detected approximately midway between the freshwater pond and the northern boundary of the site (SB-17).

Aluminum, barium, manganese and arsenic were the only inorganic constituents detected in groundwater at concentrations above expected levels for trace metals. As with the organic compounds, the extent of migration may be limited.

Elevated total cyanide concentrations were detected in surface and upper soil boring samples. The higher levels of cyanide were not detected outside of the areas discussed in the dot list above. Total cyanide concentrations in groundwater were not excessively high.

Concentrations of inorganic parameters in surface water and sediments from the Blue River adjacent to the site were not significantly above those upstream from the Site boundary, with the possible exception of copper and zinc in sediments. A slight increase in cyanide concentrations was observed adjacent to the site as compared to upstream concentrations. Concentrations of inorganic parameters in on-site surface waters and sediments were elevated in the vicinity of SW-9, SW-10, SW-11, and SW-12.

7.4 Fate and Transport.

The distribution of contaminants in on-site soils affects current and potential migration to other media. Contaminants currently at or near the surface and adsorbed to soil particulates (metals, total cyanide, PAHs) are most likely to migrate with surface water runoff, erosion and to a lesser extent with airborne dust. However, during normal runoff conditions, migration would be to the center of the southeast area as opposed to off-site via the Blue River with the exception of one small low area near the collapsed WRR garage. Future potential for the migration of site contaminants into the Blue River as a result of surface water runoff and/or erosion would only occur during flood conditions.

Contaminants currently in subsurface soils (chlorinated ethenes, chlorinated ethanes and toluene) migrate through the soil phase and into the water table with groundwater recharge. This process appears to have taken place at the Site. The predominant site-related contaminants in the upper aquifer are the chlorinated ethenes, chlorinated ethanes and, to a lesser extent, toluene. Most of the contamination is adjacent to the Blue River and will probably migrate towards the river. However, current data suggest that no large scale migration of contaminants to the river is occurring. Although, chlorinated ethenes have been detected in the Blue River, the concentrations at all sample locations were below the contract required quantitation limit. Although there is the potential for migration beneath the river to the east, the attenuation or degradation of compounds that occurs between MW3S and MW11S suggest that contamination may not be detected east of the river. The analytical data indicate that the aquitard at the base of the upper aquifer appears to limit downward migration to the lower aquifer.

The attenuation of contaminants in soils and groundwater is controlled by many physical, chemical and biological processes. Currently biochemical degradation of the chlorinated ethenes and chlorinated ethanes appears to be taking place. The occurrence of clay and silt in area soils enhances the potential attenuation of site-related contaminants through adsorption.

7.5 Endangerment Assessment.

An assessment of public and environmental health risks was conducted for the WRR Site. The process was made up of four components as suggested in the Superfund Public Health Evaluation Manual (U.S. EPA, 1986): indicator chemical selection, toxicity evaluation, exposure assessment and risk characterization.



As a result of the indicator selection process used, vinyl chloride, 1,2-dichloroethene, trichloroethene, toluene, bis(2-ethylhexyl)phthalate, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), cadmium, chromium, nickel, arsenic, cyanide, and zinc were considered to represent the greatest potential public health threat of the contaminants detected at the site.

Two exposure scenarios were evaluated in the baseline risk assessment: current site (use) conditions and plausible future site (use) conditions. The current use scenario evaluated exposures to potential trespassers on-site. The site is zoned for industrial use, thus, for future site conditions, it was assumed that the site may be developed and that construction workers would be exposed to surface and subsurface contaminants. It was also assumed for the future use scenario that Municipal Well #8 may be contaminated (i.e., drawing groundwater from the contaminated aquifer) under an increased demand for its use as the area develops. In addition, assumptions were applied to estimate potential risk should groundwater contaminants migrate to existing private wells.

Both current and future use scenarios were based on the premise that no action would be taken to mitigate release of contaminants from the site and no restrictions would be imposed.

Based on current use conditions at the site, no risks were identified through exposure to contaminated groundwater. Under current conditions, only trespassers were identified as incurring some potential risk, through exposure to contaminated soils. Actual risk to trespassers is likely to be much lower than the calculated risk because the contaminants that contributed to the majority of the risk occur in discrete, localized areas. In addition, the number of individuals likely to trespass on the site is probably very low, thus further reducing the potential for exposure at the site.

Under the assumptions made to assess future site conditions, risks from exposure to contaminated soils were estimated for construction workers potentially working at the site in the future. As described above for site trespassers, actual risks associated with this activity would be very low because the areas of contaminated soils are localized. In addition, the number of exposed individuals would be small, thus reducing the probability of contact. Under future site assumptions, risks were estimated for users of municipal water and users of private well water. However, these risks would

be realized only if there were to be a dramatic increase in the water usage by Columbia City (i.e. pumping would probably have to increase to 16 hours a day from the current 8 hours a day). In addition, the assumption that the contaminant levels at the municipal well result from simply the dilution of contaminants (by a ratio of downward flow from the upper aquifer to total flow in the municipal well) is conservative. The assumptions used in the endangerment assessment are also very conservative. The sum of all these factors may result in the actual risk being lower than the calculated risk.

The risk characterization section of Chapter 6.0 provides a detailed description of potential risks to current and future users based on the conditions and assumptions applied in this assessment. Because the final health risk estimates were ascertained by comparing estimated exposure doses (with uncertainties) with appropriate reference doses (with uncertainties), the risk estimates should only be viewed as approximate. The risks calculated should be viewed on a relative rather than actual basis. A summary of the estimated lifetime cancer risks associated with this site can be found in Table 49.

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8.0 REFERENCES

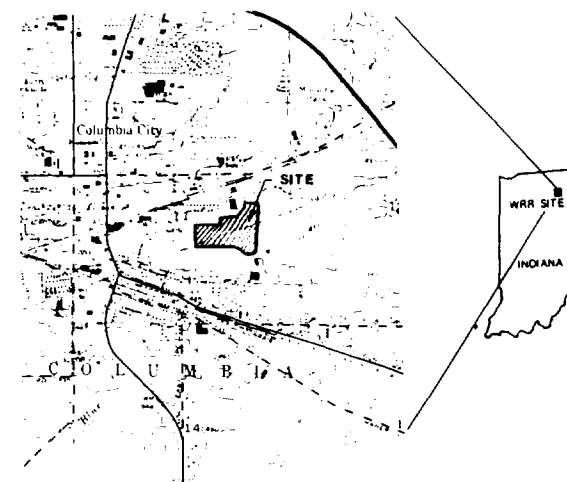
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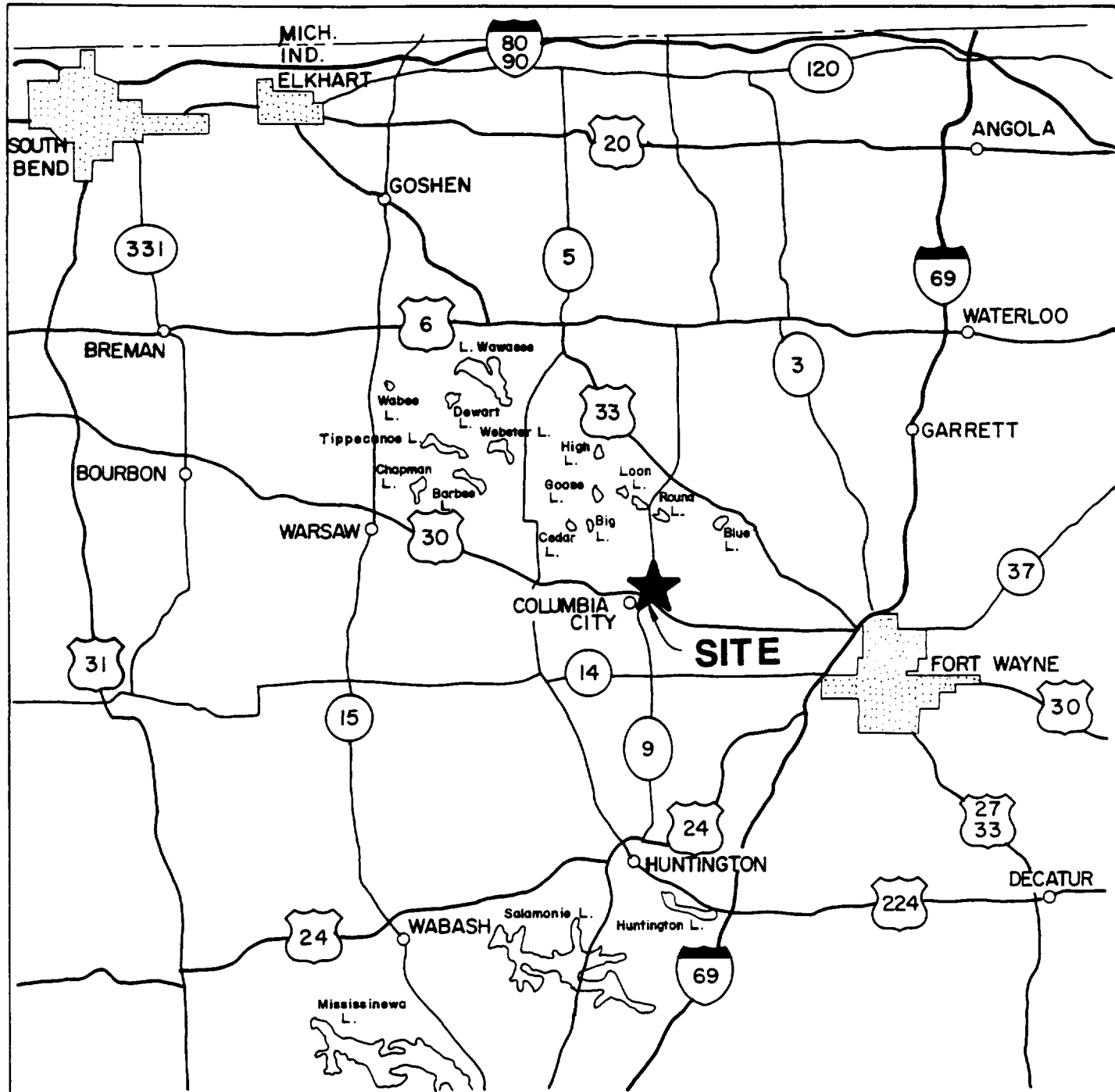
REMEDIAL INVESTIGATION REPORT **WAYNE RECLAMATION AND RECYCLING SITE** **COLUMBIA CITY, INDIANA**

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SITE LOCATION MAP



north

SCALE: 1"=10 MILES

FIGURE 1



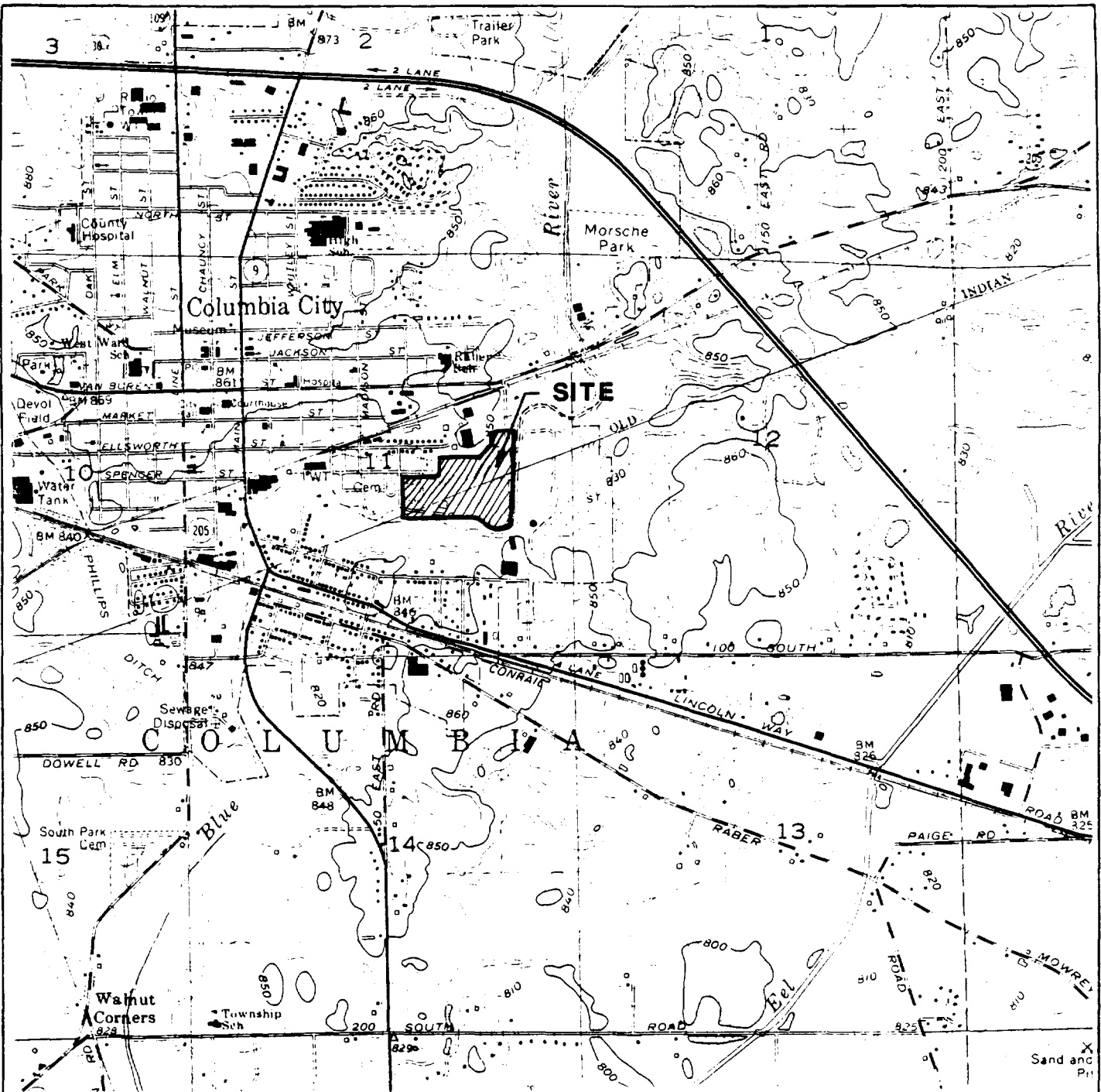
WRR RI SITE LOCATION MAP

WAYNE RECLAMATION &
RECYCLING RI/FS
COLUMBIA CITY, INDIANA

DWN D.L.L. APP'D *[Signature]* DATE 5/30/89 60128.04-A1

N67178

TELEDYNE POST



LOCATION MAP DEVELOPED FROM COLUMBIA CITY, INDIANA
 7 1/2 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP DATED 1965,
 PHOTOREVISED 1981



north

SCALE: 1"=2000'

FIGURE 2



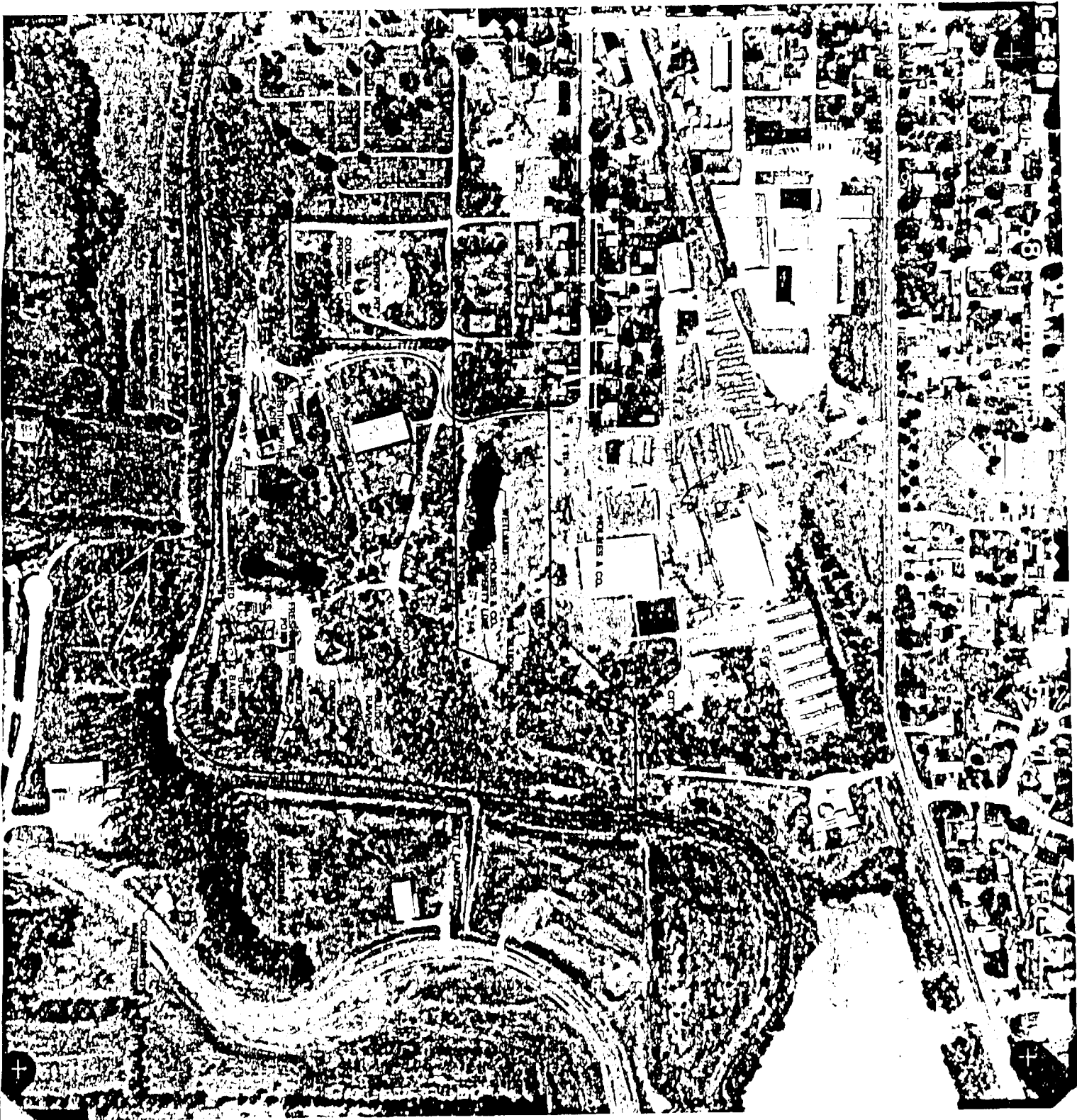
SITE LOCATION MAP

WAYNE RECLAMATION &
 RECYCLING RI/FS
 COLUMBIA CITY, INDIANA

DWN D.L.L. APPT. *[Signature]* DATE 5/30/89 60128.04-A2

N47178

TELETYPE POST



AIRIAL PHOTO DEVELOPED BY
CHRYSTAL ALLEN, NORTHEAST INDIANA
DATED MAY 11, 1988

SCALE 1" = 100' (APPROX.)
north

FIGURE 3

	<p>SITE FEATURES MAP WAYNE RECLAMATION AND RECYCLING PLANTS COLUMBIA CITY, INDIANA</p>	<p>WARZYN COLUMBIA CITY, INDIANA 46728</p>	<p>DATE: 1988 BY: [illegible] FOR: [illegible] AS SHOWN</p>
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LEGEND

- SB-99 SOIL BORING LOCATION & NUMBER (PHASE II)
- SB-00 SOIL BORING LOCATION & NUMBER (PHASE II)

NOTES:

1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM MINUS 5.06 FEET, CONTOUR INTERVAL IS 1 FORD FOOT.
3. SOIL BORINGS (SB-1 TO SB-26) FOR PHASE I WERE DRILLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
4. SOIL BORINGS (SB-A TO SB-V AND SB-27 TO SB-40) FOR PHASE II WERE DRILLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
5. LOCATION OF SOIL BORINGS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.



FIGURE 5

LEGEND
 TP1 TEST PIT LOCATION & NUMBER (PHASE 1)

- NOTES
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM PLUS 0.05 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. TEST PITS WERE PERFORMED BY ENVIRONMENTAL CLEAN-UP CONTRACTOR SERVICE, SERVICE, INC. (E.C.C.S.) UNDER THE DIRECTION OF WAREZYN ON MARCH 23, 1988.
 4. LOCATIONS OF TEST PITS WERE FIELD LOCATED BY WAREZYN SURVEYORS ON MARCH 23, 1988.

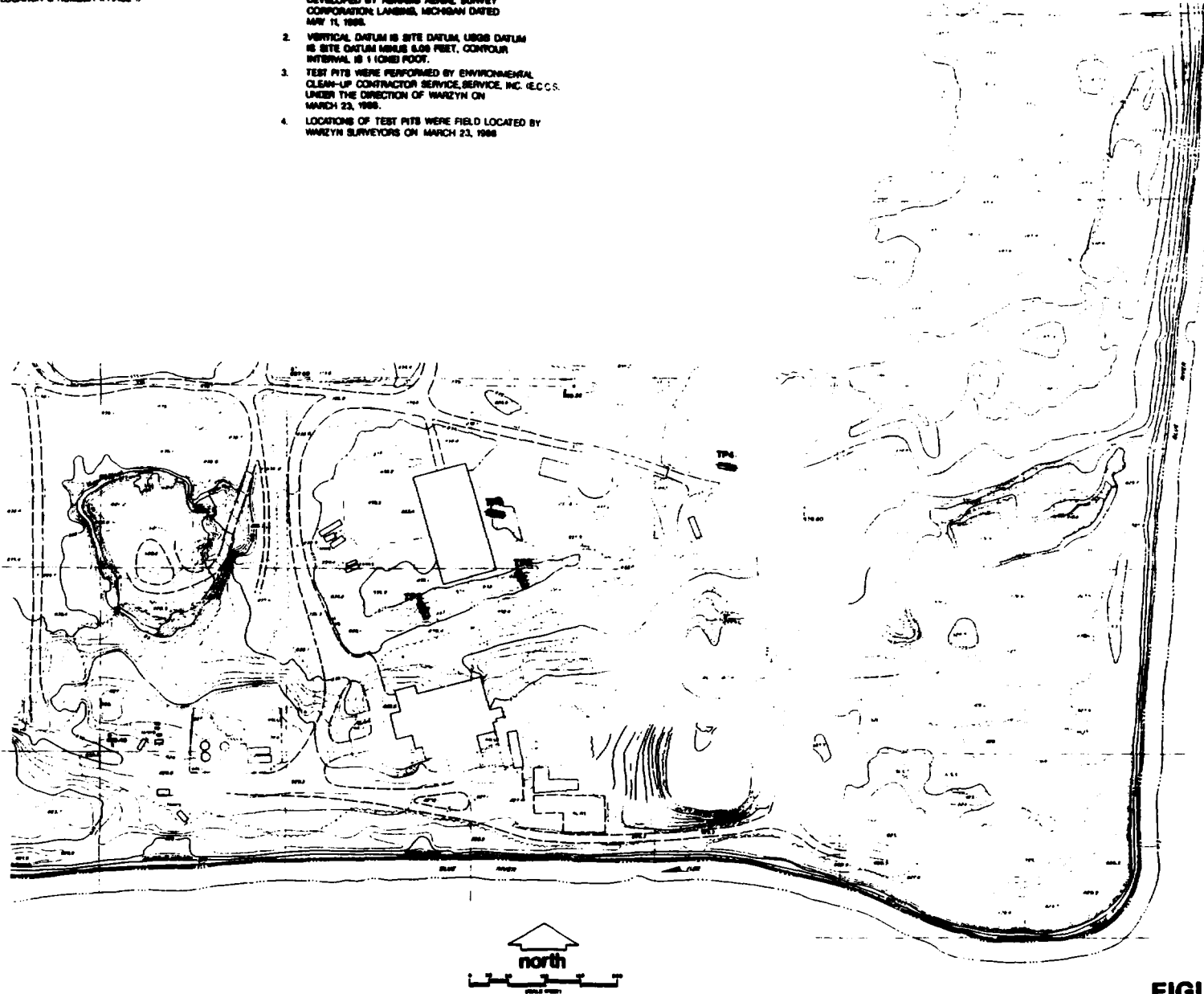


FIGURE 6

TEST PIT LOCATION MAP
 WAREZYN INVESTIGATION AND
 REMEDIATION
 COLUMBIA CITY, INDIANA

DATE: 11/11/88
 BY: WAREZYN
 CHECKED: [Signature]
 APPROVED: [Signature]

LEGEND

MW33a@ MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)

MW7a@ MONITORING WELL LOCATION & NUMBER (PHASE I)

MW13a@ MONITORING WELL LOCATION & NUMBER (PHASE II)

P4@ REZOMETER LOCATION & NUMBER (PHASE III)

SG4@ STAFF GAUGE LOCATION & NUMBER

- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, UGDS DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. MONITORING WELLS (MW33a) (SHALLOW AND DEEP), MW33b, MW33c, AND MW33d WERE DRILLED AND INSTALLED BY PEBBLEHEAD-MIDWEST INC. UNDER THE SUPERVISION OF BERANER ASSOCIATES IN MAY 1988.
 4. MONITORING WELLS MW7a TO MW7f FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS MW13a TO MW13f, MW14, MW15, MW16, MW17, AND MW18 FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. P4 WELL (P4) WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1988 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PRODS. HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.

7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 18, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.

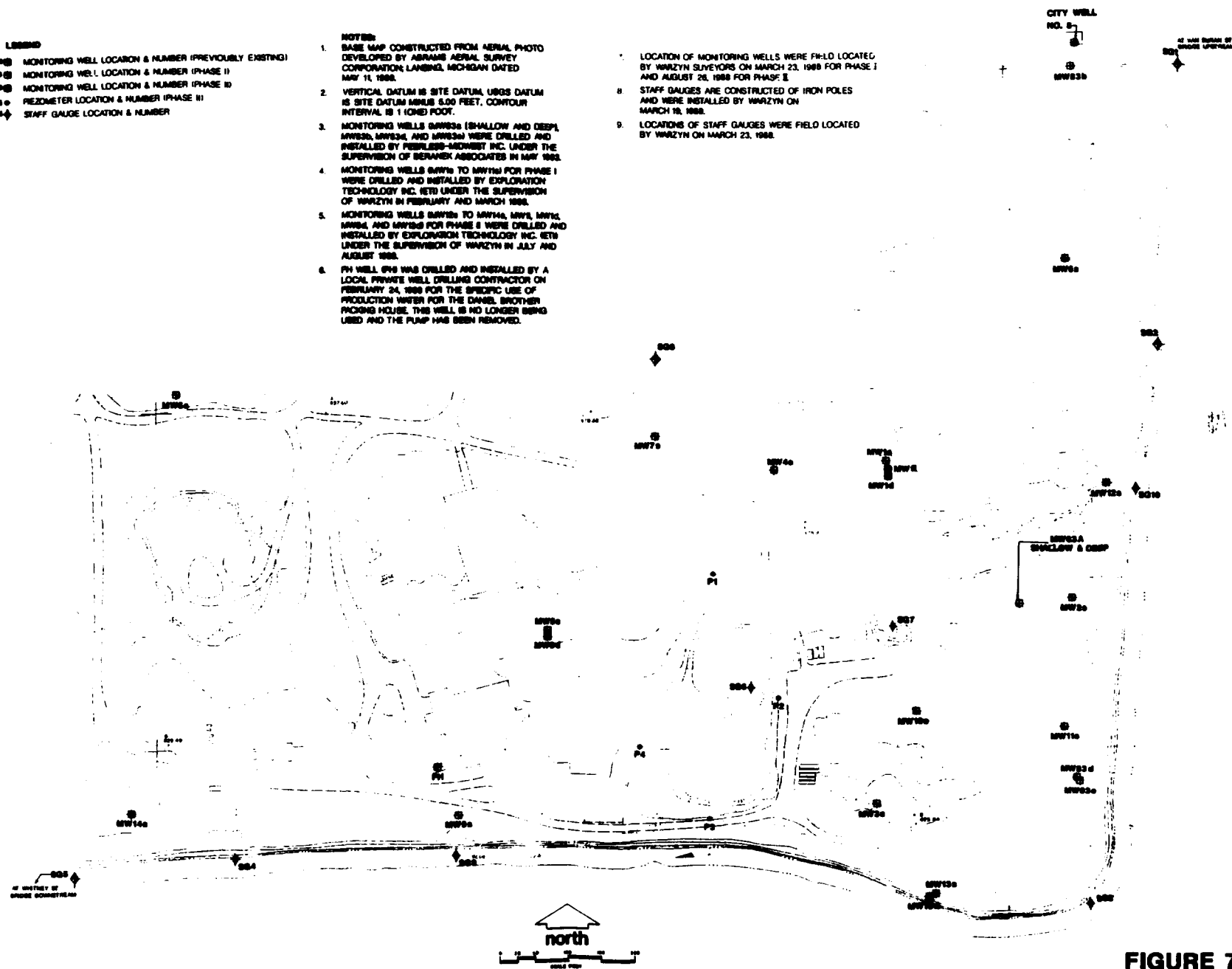


FIGURE 7

WARZYN

WARZYN WELL LOCATION MAP

WATER REGULATION AND RECYCLING RIFE

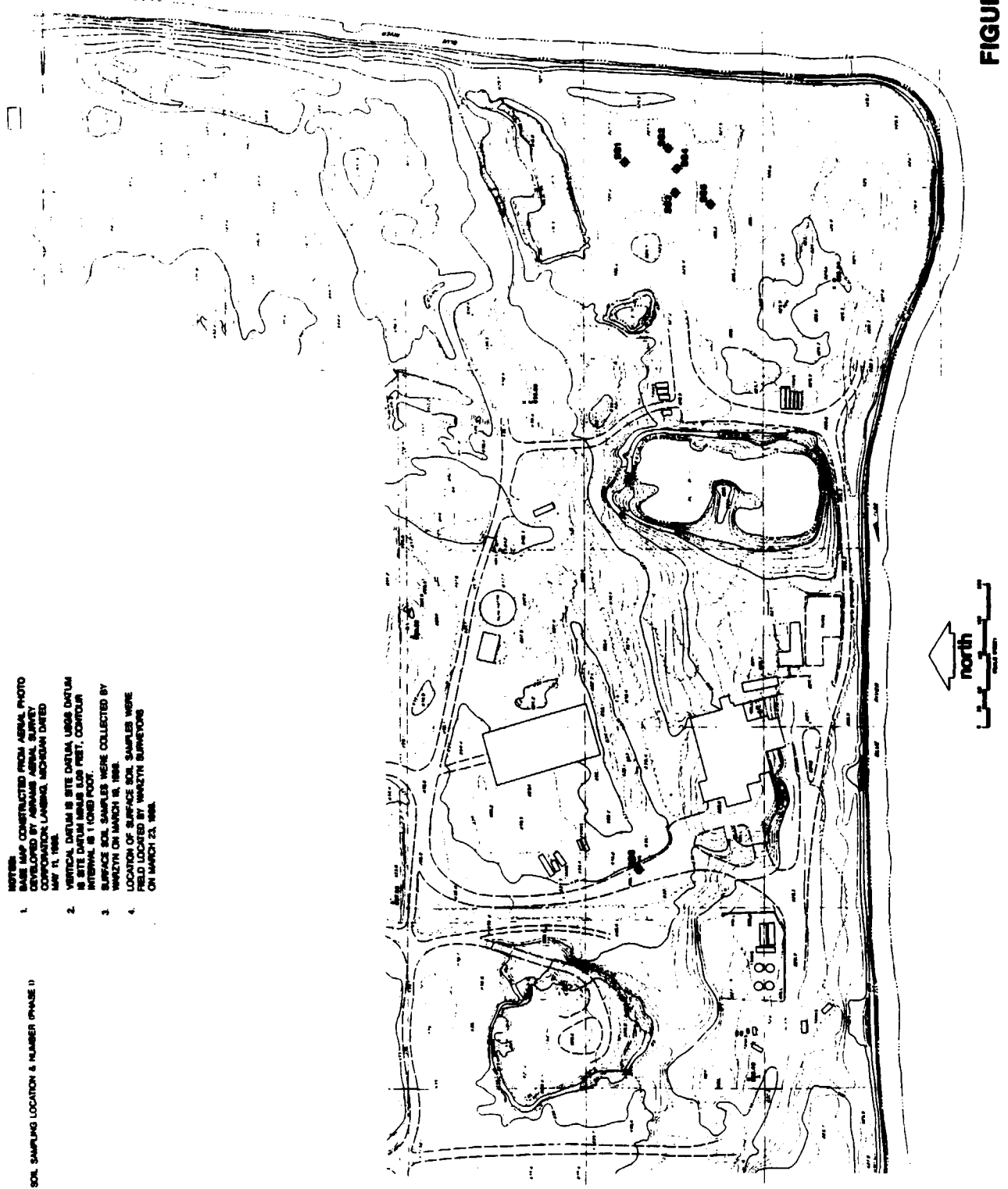
COLUMBIA CITY, INDIANA

DATE: 1/2/89

BY: [Signature]

FOR: [Signature]

SCALE: 1" = 100'



- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ARMAH AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM. USGS DATUM IS SITE DATUM. 1000 FEET. CONTAIN INTERVAL. 10 FEET.
 3. SURFACE SOIL SAMPLES WERE COLLECTED BY WMA ON MARCH 16, 1988.
 4. LOCATION OF SURFACE SOIL SAMPLES WERE INDICATED BY WHITE DOTS ON MARCH 16, 1988.

LEGEND

88-1 SURFACE SOIL SAMPLING LOCATION & NUMBER PHASE 1

FIGURE 8

1. BARE HILL WAS CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY AVIATION AERIAL SURVEY CORPORATION, LAMAR, MICHIGAN DATED MAY 11, 1966.
2. VERMILION, DUTCH IS SITE DUTCH, UDDER DUTCH IS SITE DUTCH LAMAR ROAD PEST, CONTOUR INTERVAL, IS 10000 FEET.
3. SURFACE WATER AND SEDIMENT SAMPLES WERE COLLECTED BY WYNTH ON MARCH 17 & 18, 1966.
4. LOCATION OF SURFACE WATER AND SEDIMENT SAMPLES WERE FIELD LOCATED BY WYNTH SURVEYORS ON MARCH 22, 1966.
5. SEDIMENT SAMPLES WERE COLLECTED FROM BOTH BANKS OF THE RIVER. SURFACE SAMPLES WERE TAKEN IN ALL THE LEFT BANK WOULD BE AS F YOU ARE LOOKING UPRIVER.
6. BOM WAS COLLECTED BY A SURFACE WATER RUNOFF METHOD. NO STREAMS WERE THIS PRESENT.

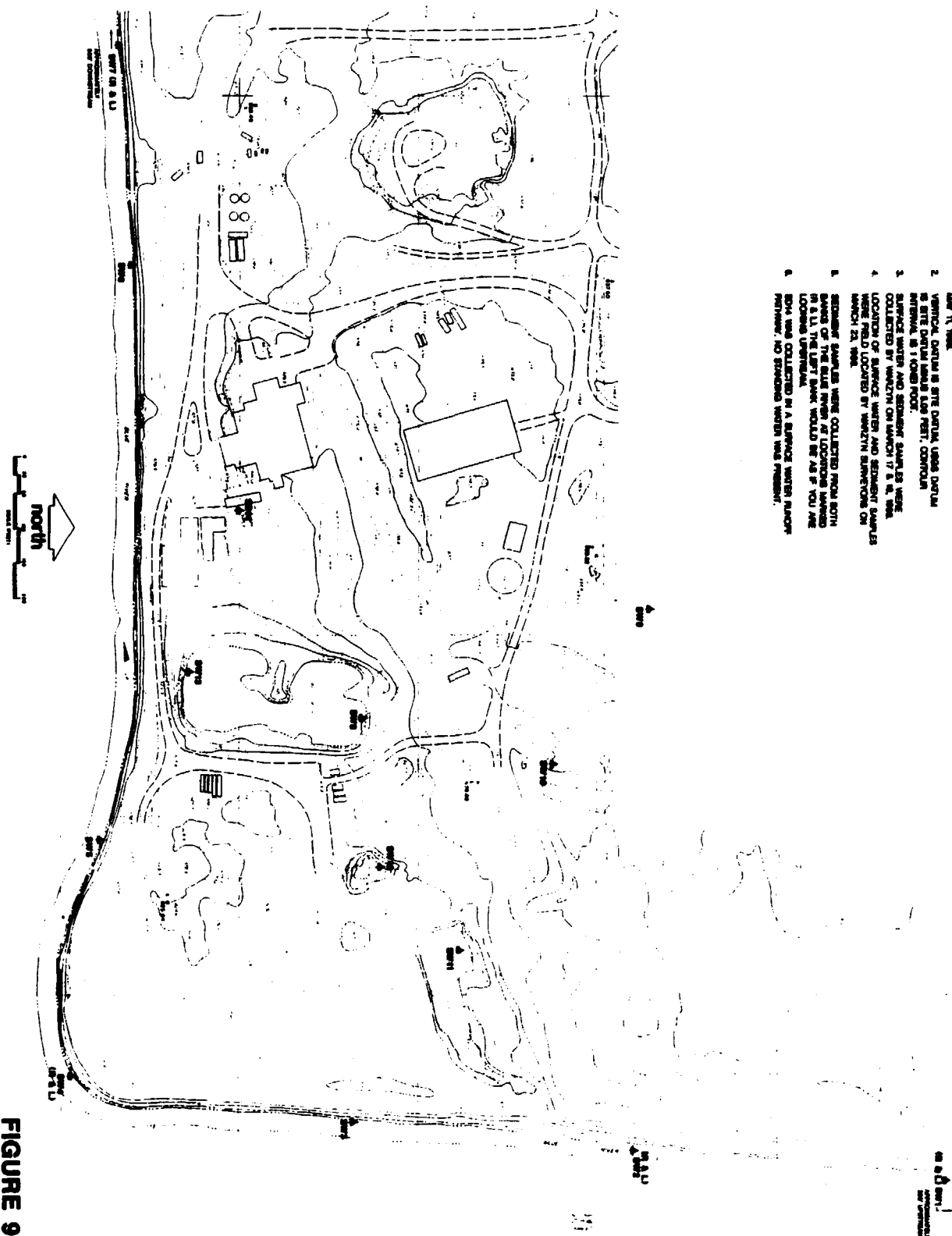
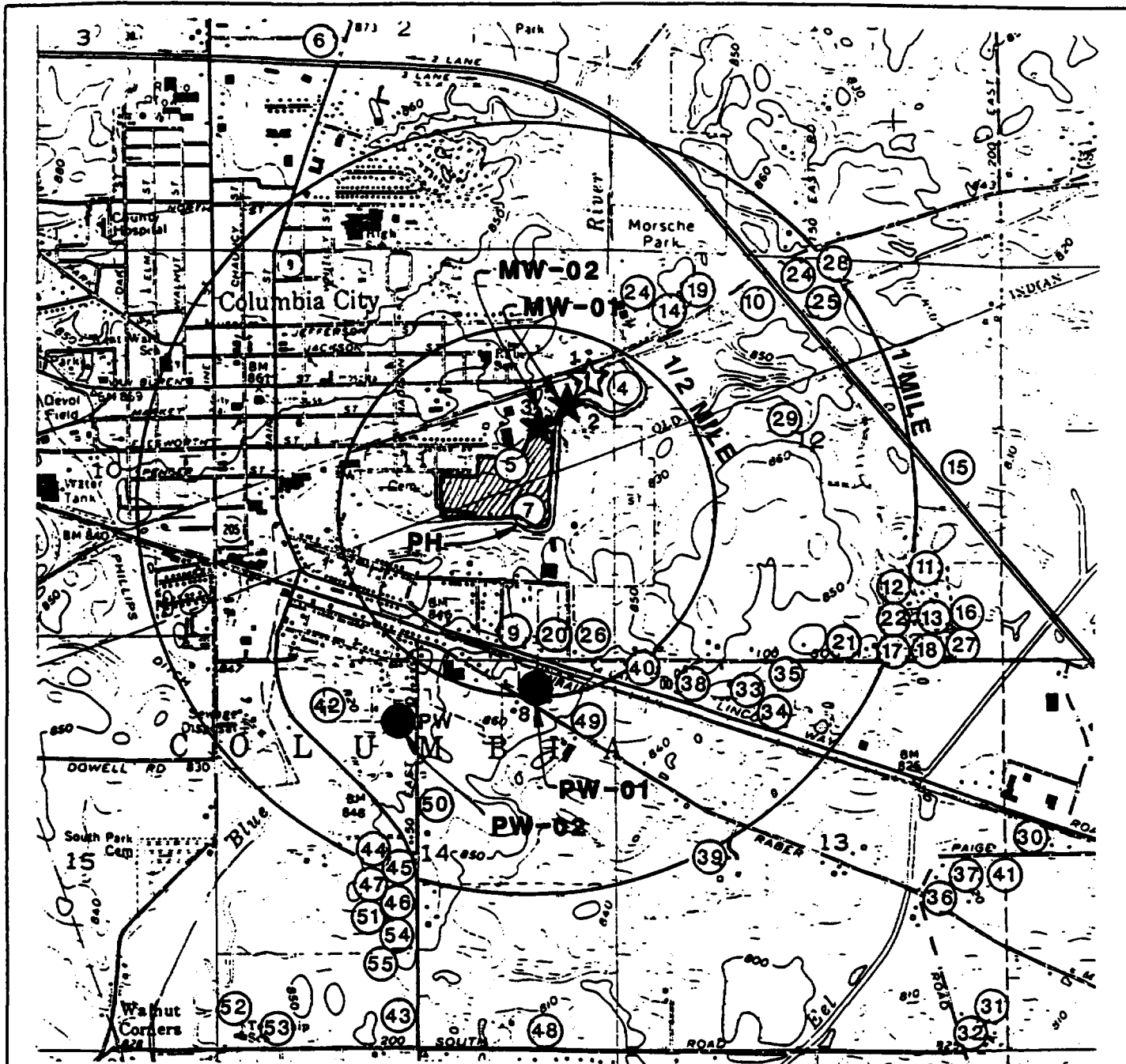






FIGURE 9



BASE MAP DEVELOPED FROM COLUMBIA CITY, INDIANA
7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAP
DATED 1965, PHOTOREVISED 1981

LEGEND

-  CITY WELL
-  PRIVATE WELL
-  PRIVATE WELL SAMPLED IN PHASE II
-  CITY WELL SAMPLED IN PHASE II



north

SCALE: 1"=2000'

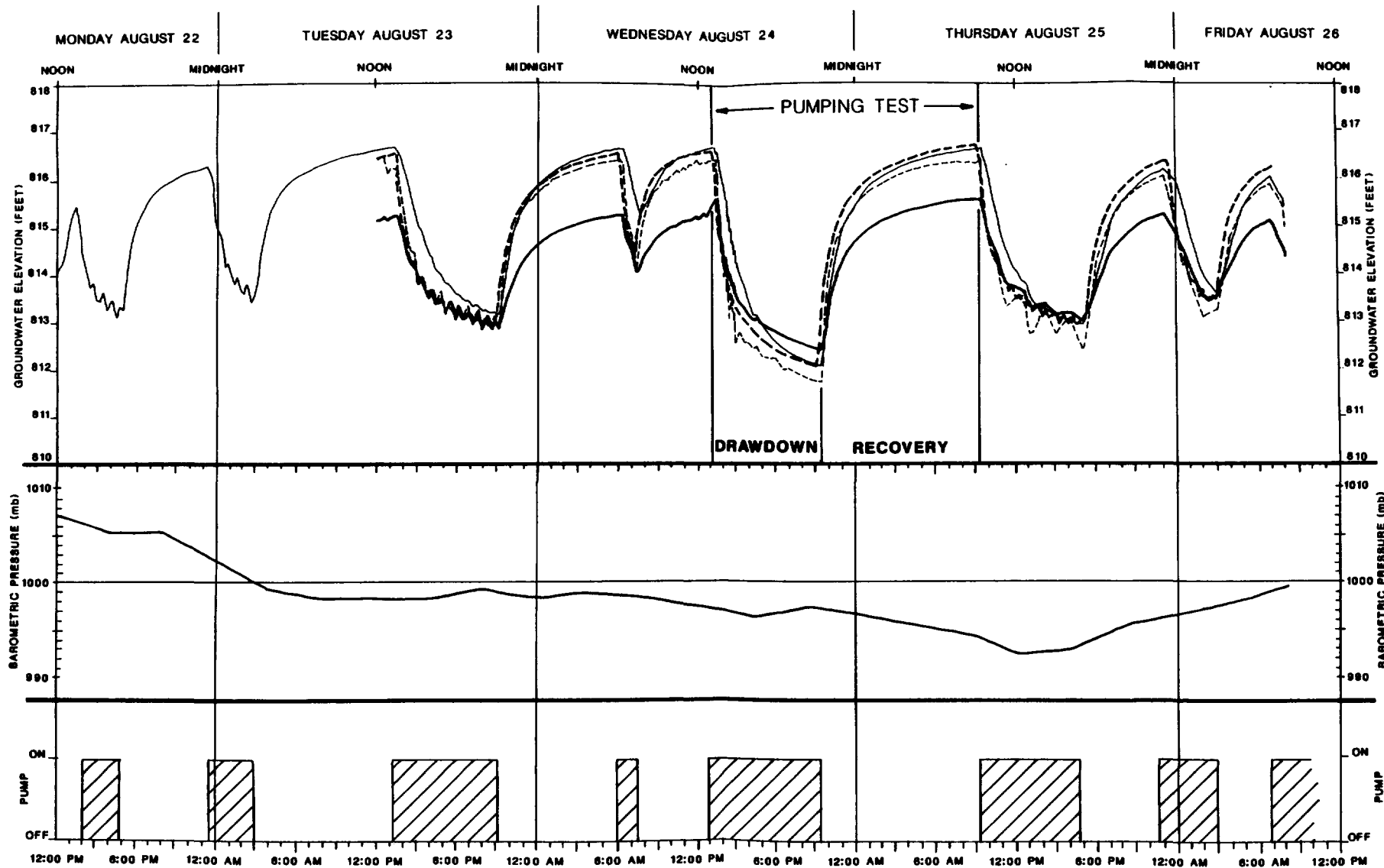
FIGURE 10

WARZYN

CITY & PRIVATE WELL LOCATION MAP

WAYNE RECLAMATION AND
RECYCLING RI/FS
COLUMBIA CITY, INDIANA

OWN D.L.L. APP'D  DATE 5/30/89 60128.04-A3



Prepared by: PJV Checked by: D.L.L. Date: 8/26/89 Drawn by: [Signature] Scale: 1" = 10'	
WARZYN WATER RESOURCES CONSULTANTS, INC. 1000 N. W. 10th St. Fort Lauderdale, FL 33304	
PUMPING SCHEDULE AND DEEP WELL RESULTS, AUGUST 22-26, 1989 WAYNE RECLAMATION AND RECYCLING RI/FS COLUMBIA CITY, INDIANA	
Project Number: 60128.04	
OF	

FIGURE 12

- LEGEND
- MW83a(1) MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)
 - MW7a(1) MONITORING WELL LOCATION & NUMBER (PHASE I)
 - MW12a(1) MONITORING WELL LOCATION & NUMBER (PHASE I)
 - SB-9(1) SOIL BORING LOCATION & NUMBER (PHASE I)
 - SB-14(1) SOIL BORING LOCATION & NUMBER (PHASE I)
 - SW7(1) SURFACE WATER AND SEDIMENT SAMPLING LOCATION & NUMBER (PHASE I)
 - SB3(1) SURFACE SOIL SAMPLING LOCATION & NUMBER (PHASE II)
 - TP1(1) TEST PIT LOCATION & NUMBER (PHASE II)
 - SG4(1) STAFF GAUGE LOCATION & NUMBER (PHASE II)
 - P4(1) PIEZOMETER LOCATION & NUMBER (PHASE II)
- A—A' CROSS SECTION LINE

- NOTES:
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1968.
 2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM MINUS 3.00 FEET. CONTOUR INTERVAL IS 1 (ONE) FOOT.

3. MONITORING WELLS MW83a(1) [SHALLOW AND DEEP], MW83b(1), MW83c(1), AND MW83d(1) WERE DRILLED AND INSTALLED BY PEERLESS-MIDWEST INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1983.
4. MONITORING WELLS MW11a(1) TO MW11d(1) FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
5. MONITORING WELLS MW12a(1) TO MW12d(1), MW13(1), MW14(1), MW15(1), AND MW16(1) FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
6. PH WELL 174 WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1980 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.
7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 18, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.
10. TEST PITS WERE PERFORMED BY ENVIRONMENTAL CLEAN-UP CONTRACTOR SERVICE, INC. (E.C.C.) UNDER THE DIRECTION OF WARZYN ON MARCH 23, 1988.
11. LOCATIONS OF TEST PITS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988.
12. SOIL BORINGS (SB-1 TO SB-26) FOR PHASE I WERE DRILLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
13. SOIL BORINGS (SB-A TO SB-V AND SB-27 TO SB-40) FOR PHASE II WERE DRILLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
14. LOCATION OF SOIL BORINGS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
15. SURFACE SOIL SAMPLES WERE COLLECTED BY WARZYN ON MARCH 18, 1988.
16. LOCATION OF SURFACE SOIL SAMPLES WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988.
17. SURFACE WATER AND SEDIMENT SAMPLES WERE COLLECTED BY WARZYN ON MARCH 17 & 18, 1988.
18. LOCATION OF SURFACE WATER AND SEDIMENT SAMPLES WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988.
19. SEDIMENT SAMPLES WERE COLLECTED FROM BOTH BANKS OF THE BLUE RIVER AT LOCATIONS MARKED (IR & L). THE LEFT BANK WOULD BE AS IF YOU ARE LOOKING UPSTREAM.
20. SD14 WAS COLLECTED IN A SURFACE WATER RUNOFF PATHWAY. NO STANDING WATER WAS PRESENT.

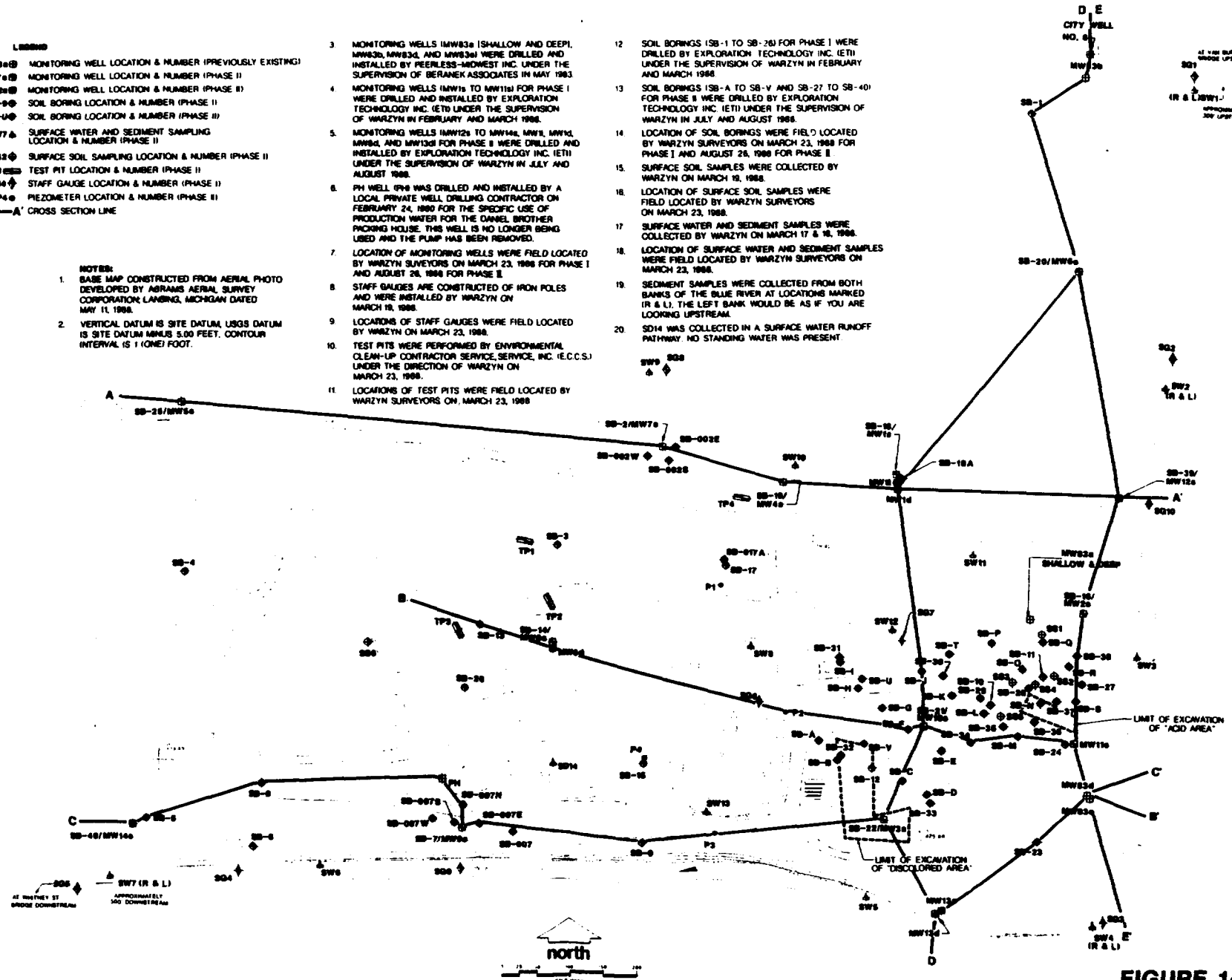


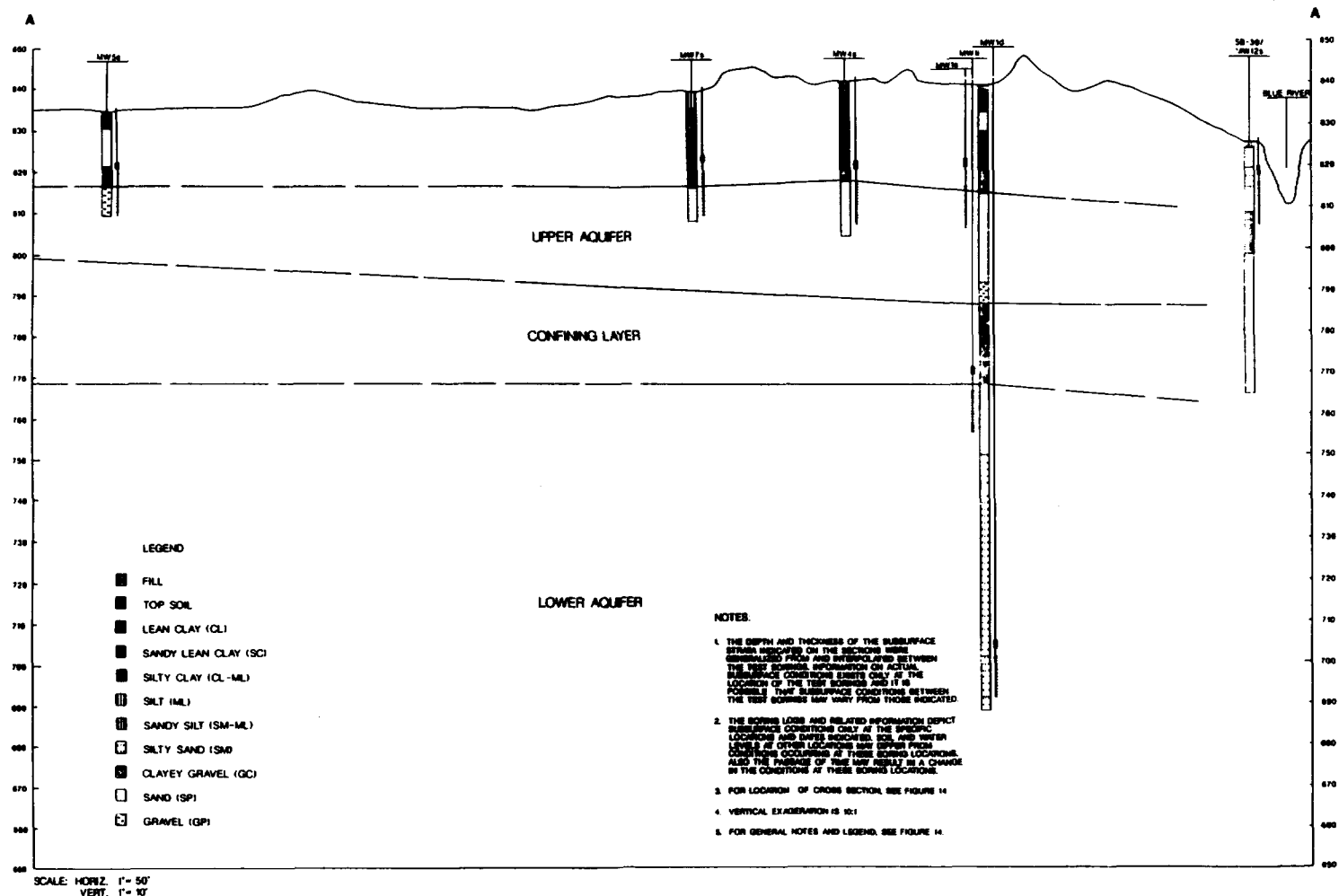
FIGURE 14

WARZYN
COLUMBIA CITY, INDIANA

DATE: 10/1/88
BY: JLV
CHECKED BY: JLV
APPROVED BY: JLV

WARZYN
COLUMBIA CITY, INDIANA

DATE: 10/1/88
BY: JLV
CHECKED BY: JLV
APPROVED BY: JLV



A - A'

FIGURE 15

DESIGNED BY: J. M. ...

CHECKED BY: ...

DATE: ...

PROJECT: ...

LOCATION: ...

SCALE: ...

APPROVED BY: ...

DATE: ...

PROJECT: ...

LOCATION: ...

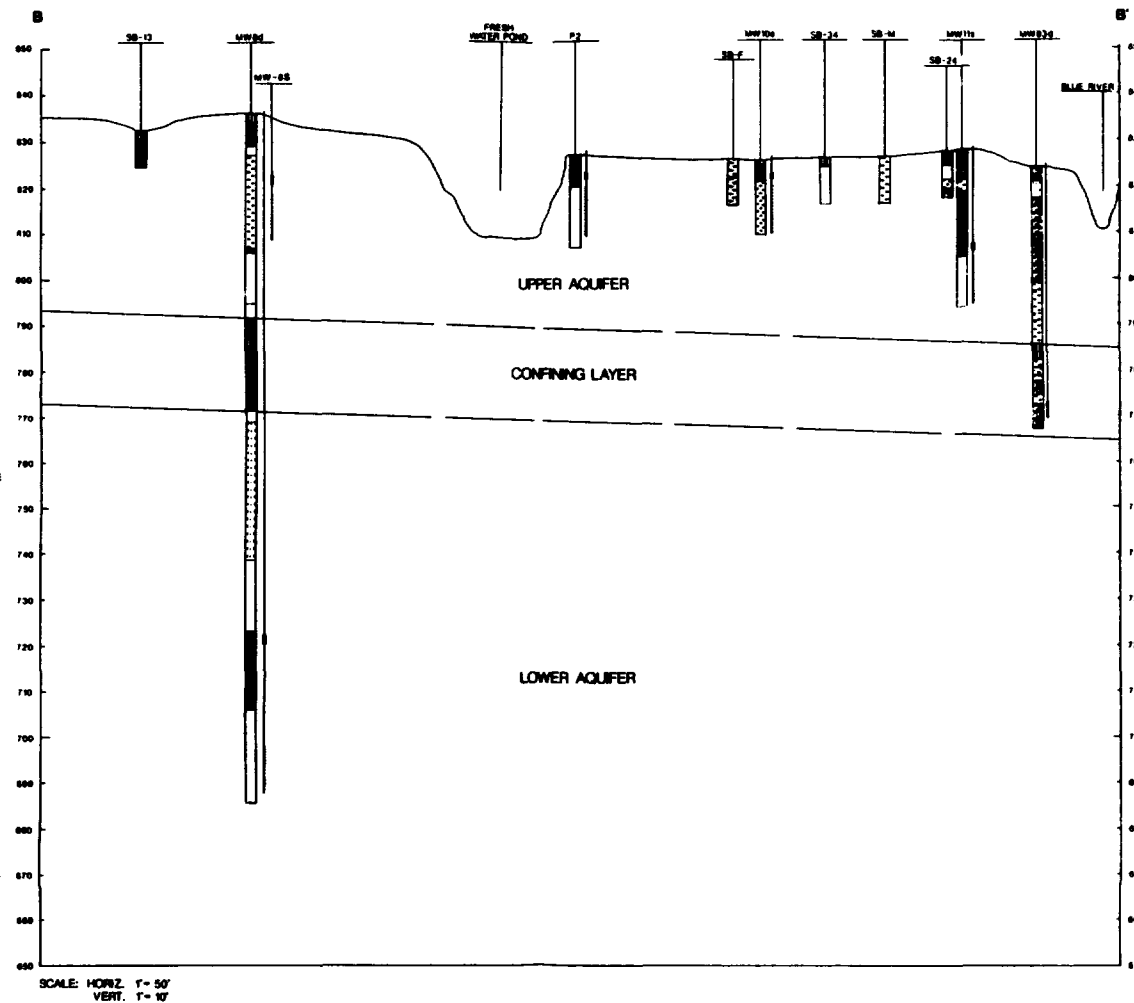
SCALE: ...

NOTES:

1. THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE GENERALIZED FROM AND INTERPOLATED BETWEEN THE TEST BORINGS. INFORMATION ON ACTUAL SUBSURFACE CONDITIONS EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.
2. THE BORING LOGS AND RELATED INFORMATION REFLECT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS INDICATED AT THESE BORING LOCATIONS. ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS.
3. FOR LOCATION OF CROSS SECTION, SEE FIGURE 14.
4. VERTICAL EXAGGERATION IS 10:1.
5. FOR GENERAL NOTES AND LEGEND, SEE FIGURE 14.

LEGEND

- FILL
- TOP SOIL
- LEAN CLAY (CL)
- SANDY LEAN CLAY (SC)
- SILTY CLAY (CL-ML)
- SILT (ML)
- SANDY SILT (SM-ML)
- SILTY SAND (SM)
- CLAYEY GRAVEL (GC)
- SAND (SP)
- GRAVEL (GP)



B - B'

FIGURE 16

PROJECT: **WATER RECLAMATION AND RECYCLING IN/UP COLUMBIA CITY, INDIANA**
 DRAWING: **SECTION B - B'**
 DATE: **3/10/99**
 DESIGNED BY: **[Signature]**
 CHECKED BY: **[Signature]**
 IN CHARGE: **[Signature]**
 SCALE: **AS SHOWN**
 SHEET: **16** OF **16**



FIGURE 17

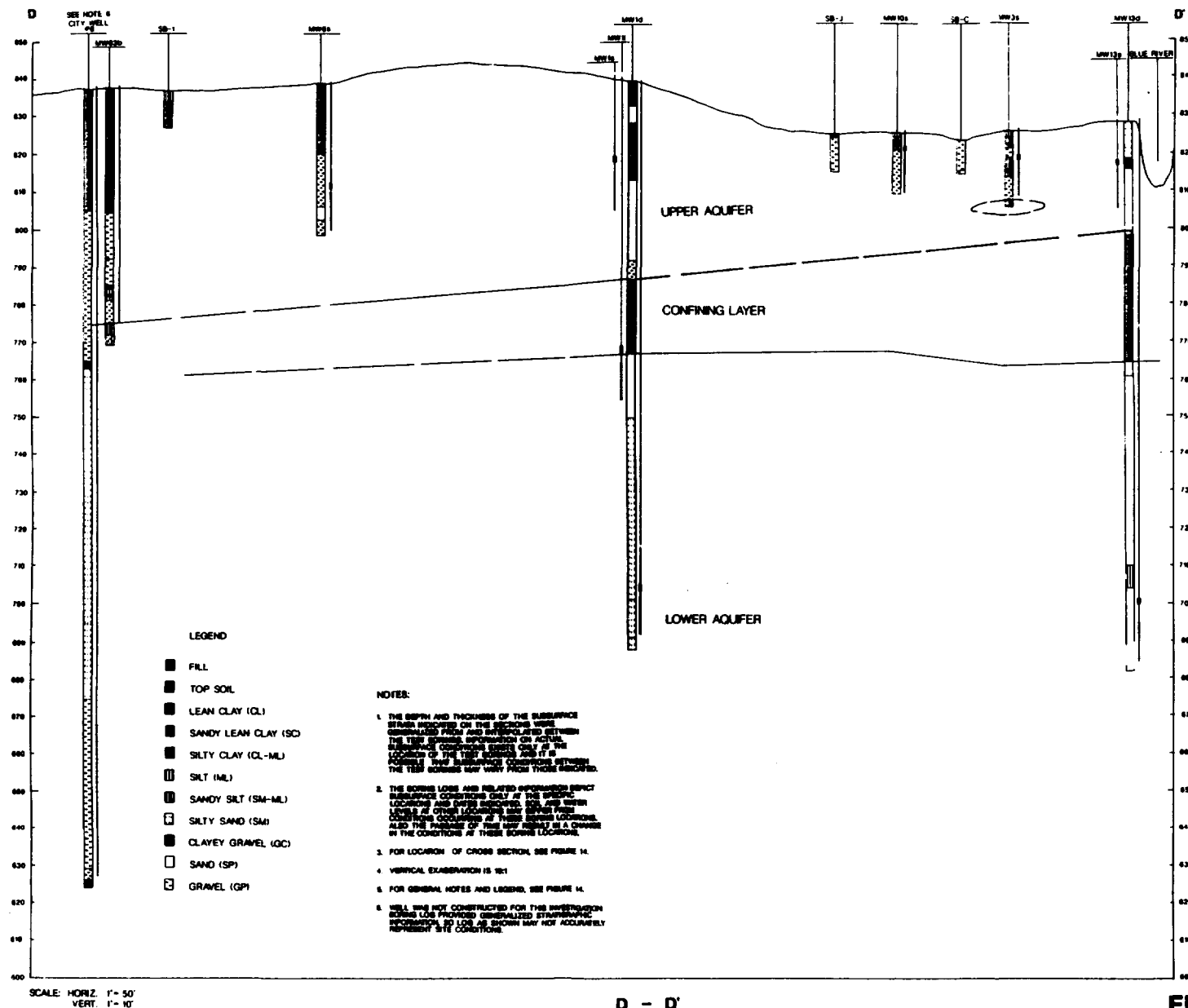
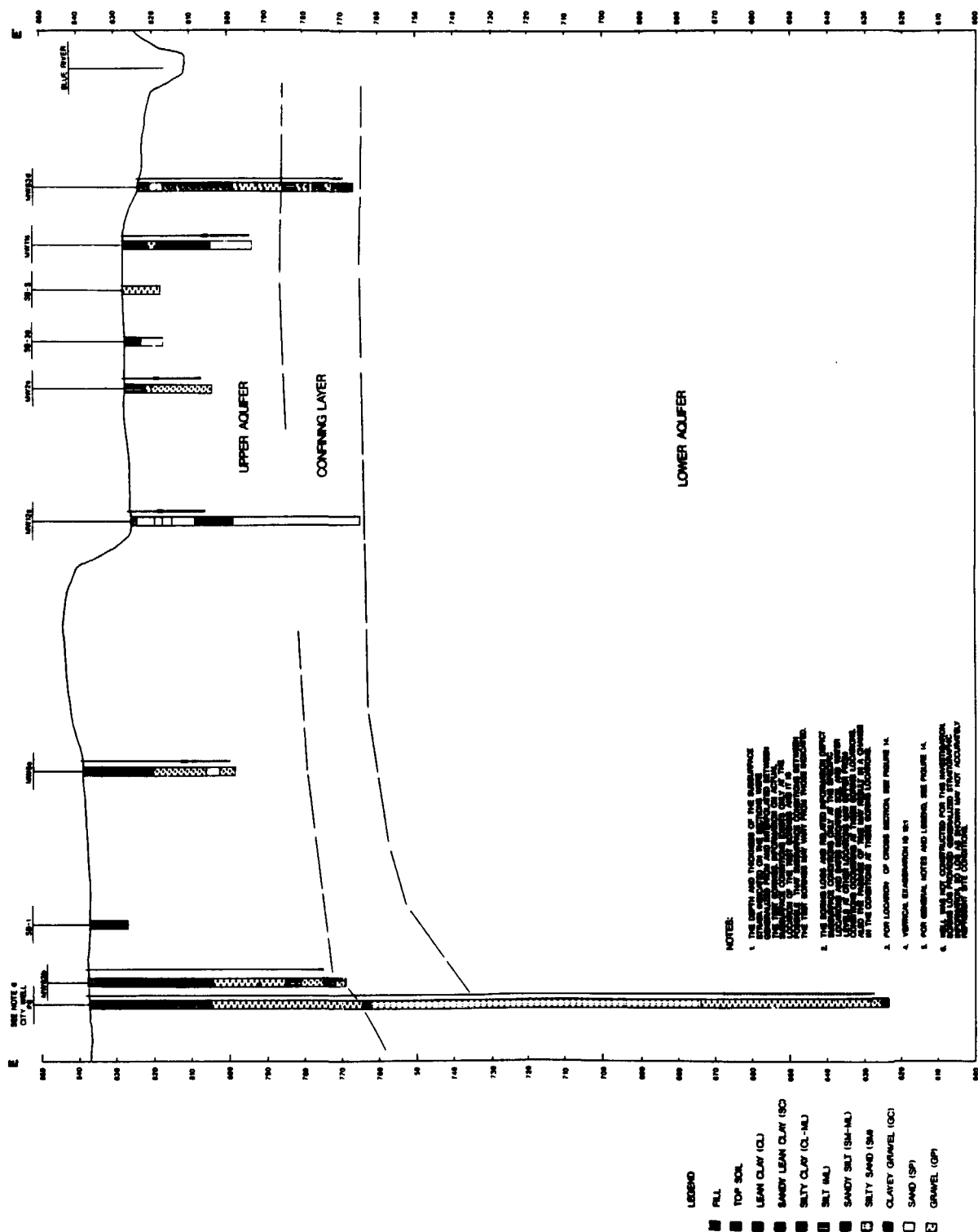


FIGURE 18

PROJECT: **WAVE RECLAMATION AND RECYCLING R/F'S**
 LOCATION: **COLUMBIA CITY, INDIANA**
 DRAWN BY: **JIM**
 CHECKED BY: **DL**
 DATE: **3/17/77**
 SCALE: **AS SHOWN**
 SHEET: **18** OF **20**



MW134a) MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)
 MW17c) MONITORING WELL LOCATION & NUMBER (PHASE I)
 MW12b) MONITORING WELL LOCATION & NUMBER (PHASE II)
 P & S
 3044) PIEZOMETER LOCATION & NUMBER (PHASE II)
 STAFF GAUGE LOCATION & NUMBER
 POTENTIOMETRIC CONTOUR LINE
 ESTIMATED POTENTIOMETRIC CONTOUR LINE
 00.25) WATER ELEVATION MEASURED AT MONITORING
 WELL AFTER RECOVERY.

- NOTES:
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION; LANSING, MICHIGAN DATED MAY 11, 1968.
 2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM PLUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. MONITORING WELLS MW183a (SHALLOW) AND DEEP MW183b, MW183d, AND MW183e WERE DRILLED AND INSTALLED BY PEERLESS-WIDWEST INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1983.
 4. MONITORING WELLS MW11a TO MW11e FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS MW112b TO MW114a, MW11f, MW11g, MW11h, AND MW11i FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. PH WELL #14 WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1989 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.
 7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 28, 1988 FOR PHASE II.
 8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 19, 1988.
 9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.
- 8176
- 8174
- 8172

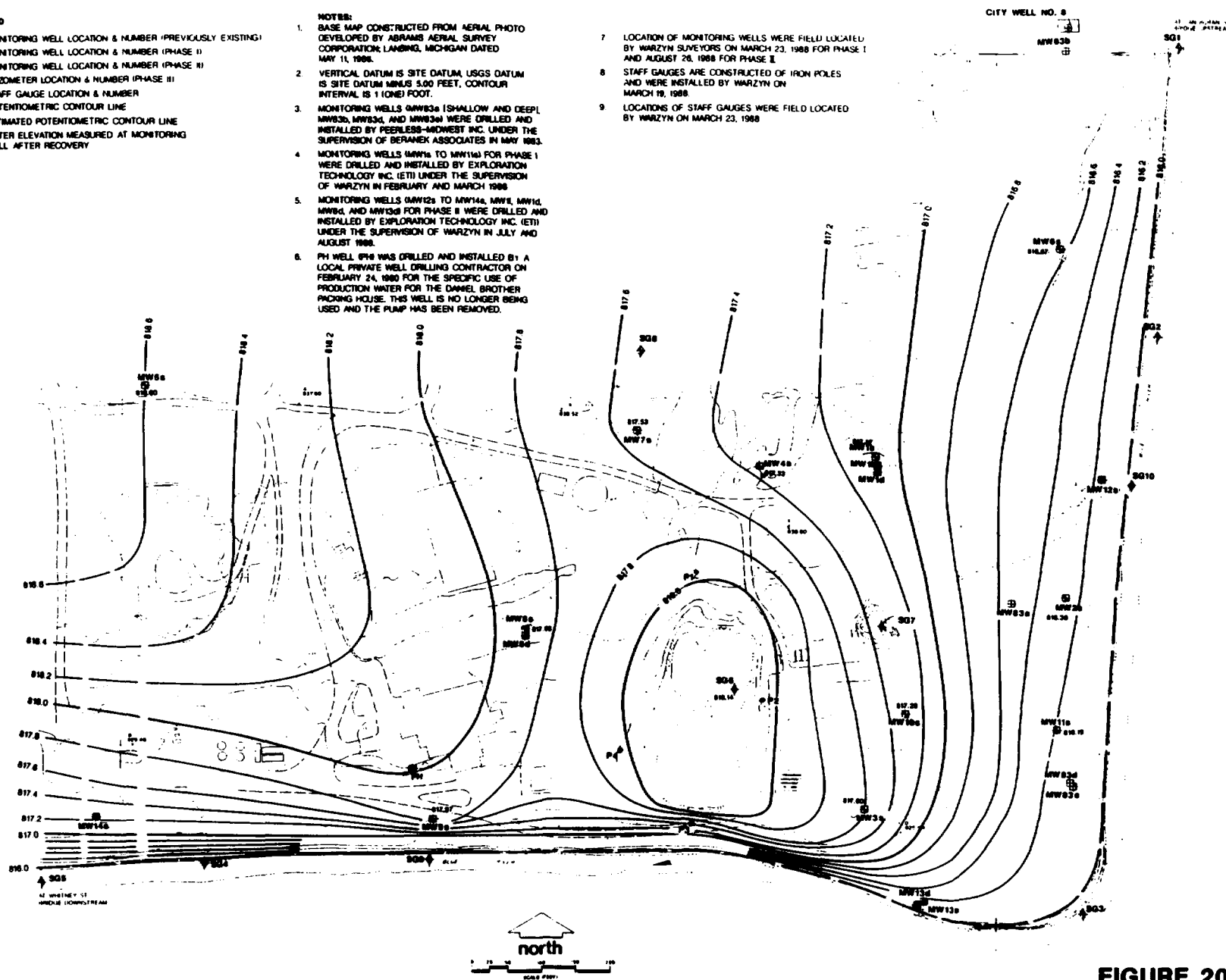
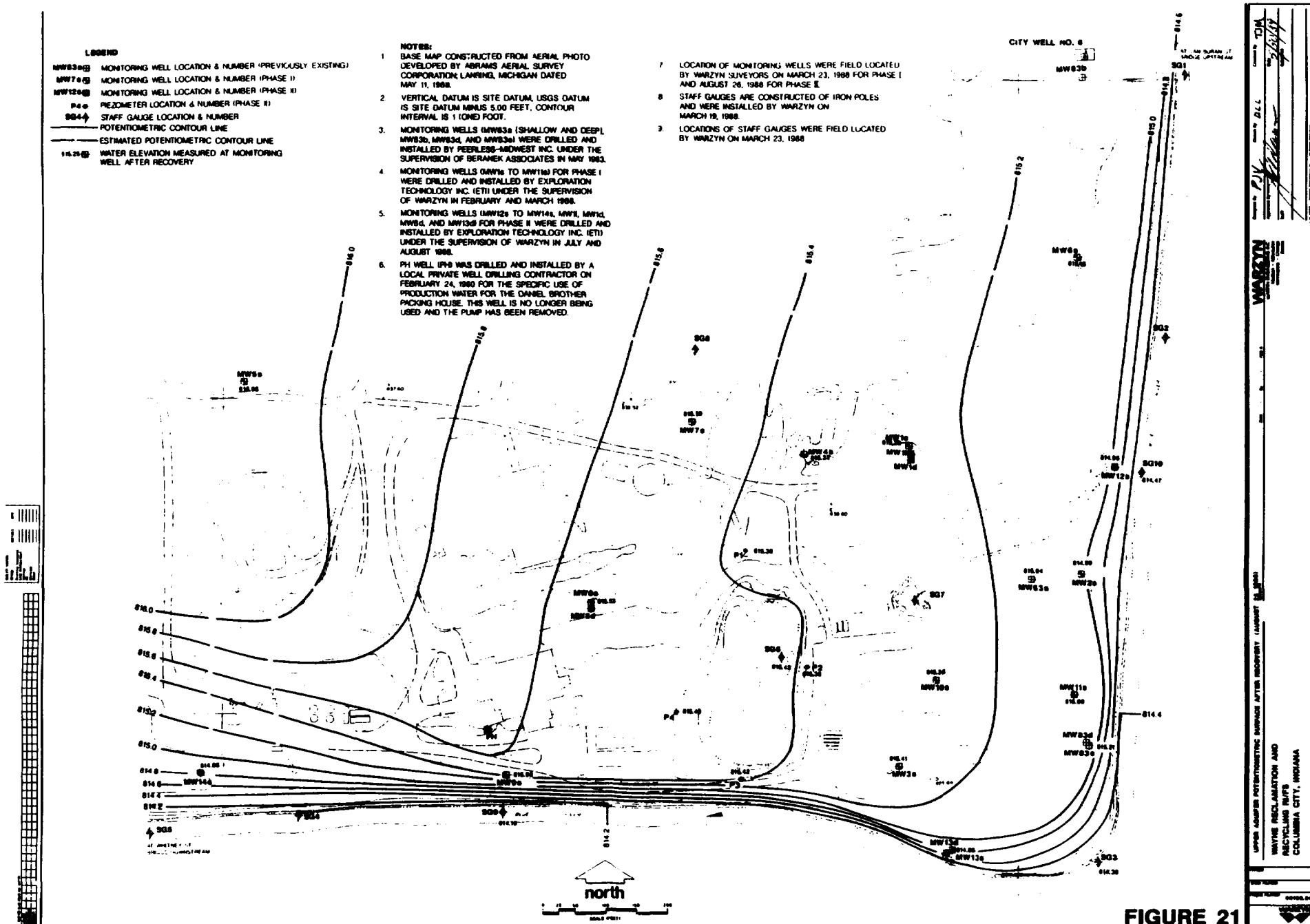


FIGURE 20



- LEGEND**
- MW630 MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)
 - MW700 MONITORING WELL LOCATION & NUMBER (PHASE I)
 - MW1200 MONITORING WELL LOCATION & NUMBER (PHASE II)
 - P40 REZOMETER LOCATION & NUMBER (PHASE II)
 - SG4 STAFF GAUGE LOCATION & NUMBER
 - POTENTIOMETRIC CONTOUR LINE
 - ESTIMATED POTENTIOMETRIC CONTOUR LINE
 - 98.20 WATER ELEVATION MEASURED AT MONITORING WELL AFTER 8 HOUR PUMPING TEST

- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, USGS. DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. MONITORING WELLS MW630 (SHALLOW AND DEEP), MW630, MW630d, AND MW630e WERE DRILLED AND INSTALLED BY PERLESS-MOORE INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1983.
 4. MONITORING WELLS (MW100 TO MW110) FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS (MW120 TO MW140, MW140, MW140d, AND MW140e) FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. PH WELL P40 WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1988 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.

7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 19, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.

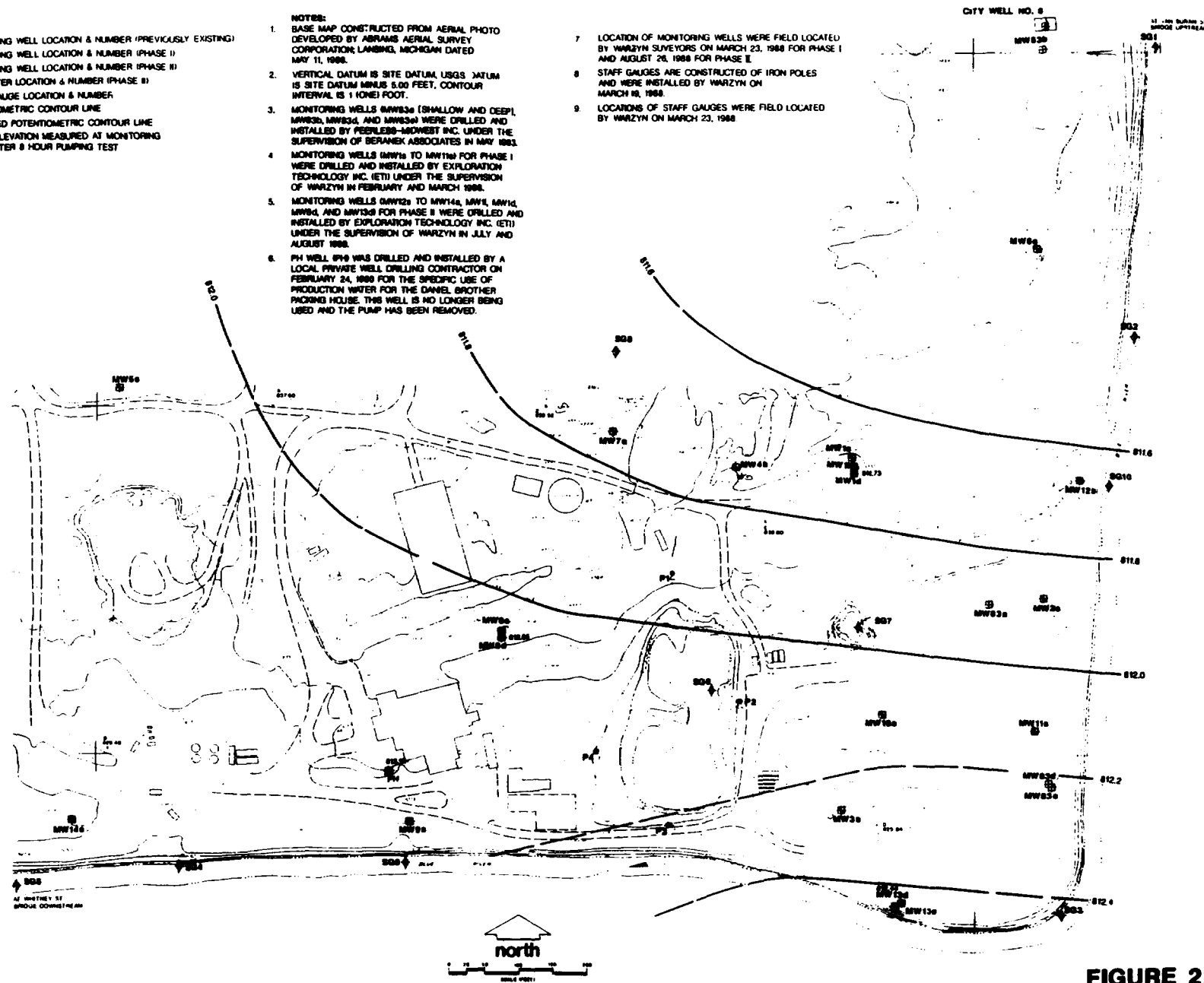
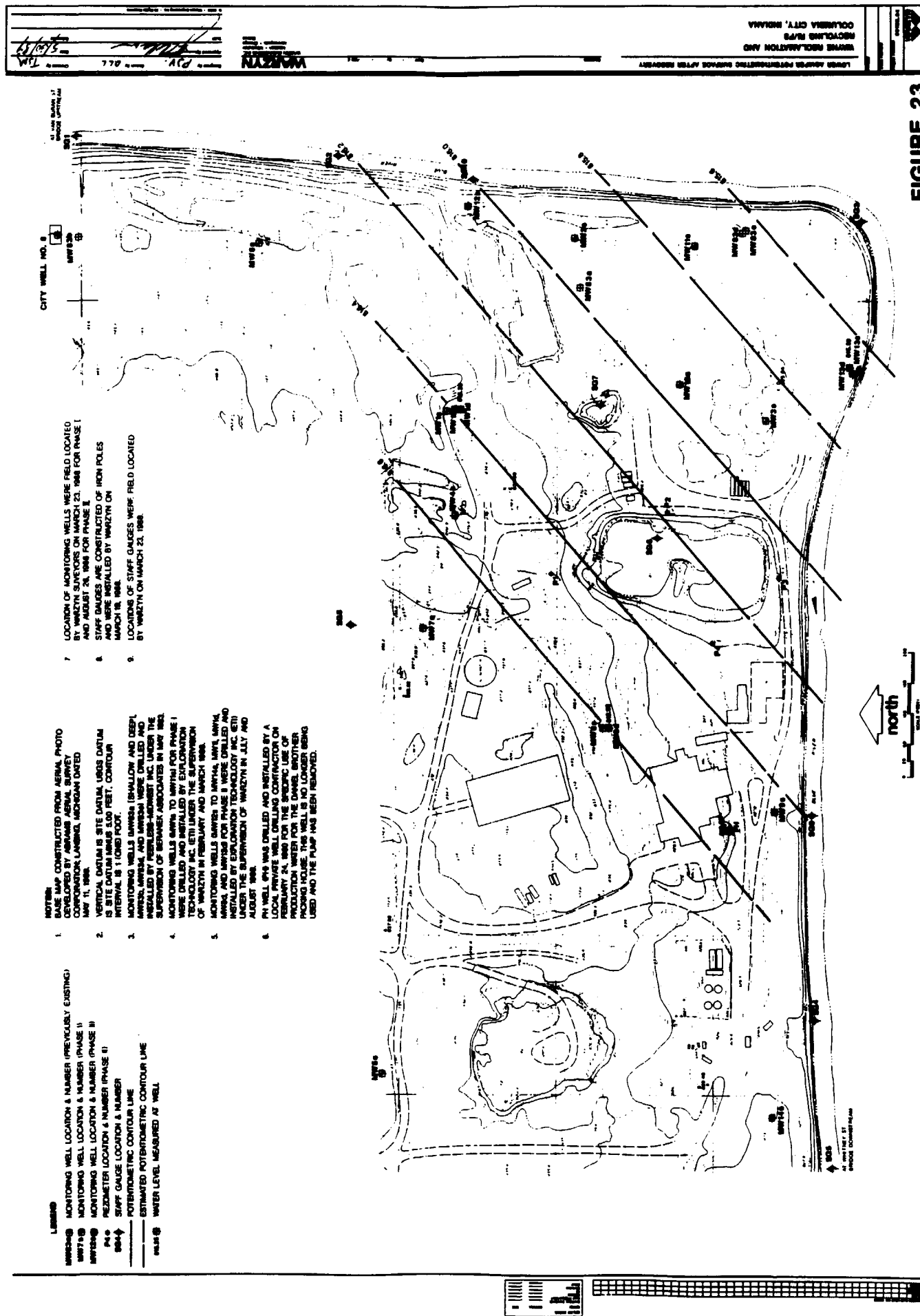


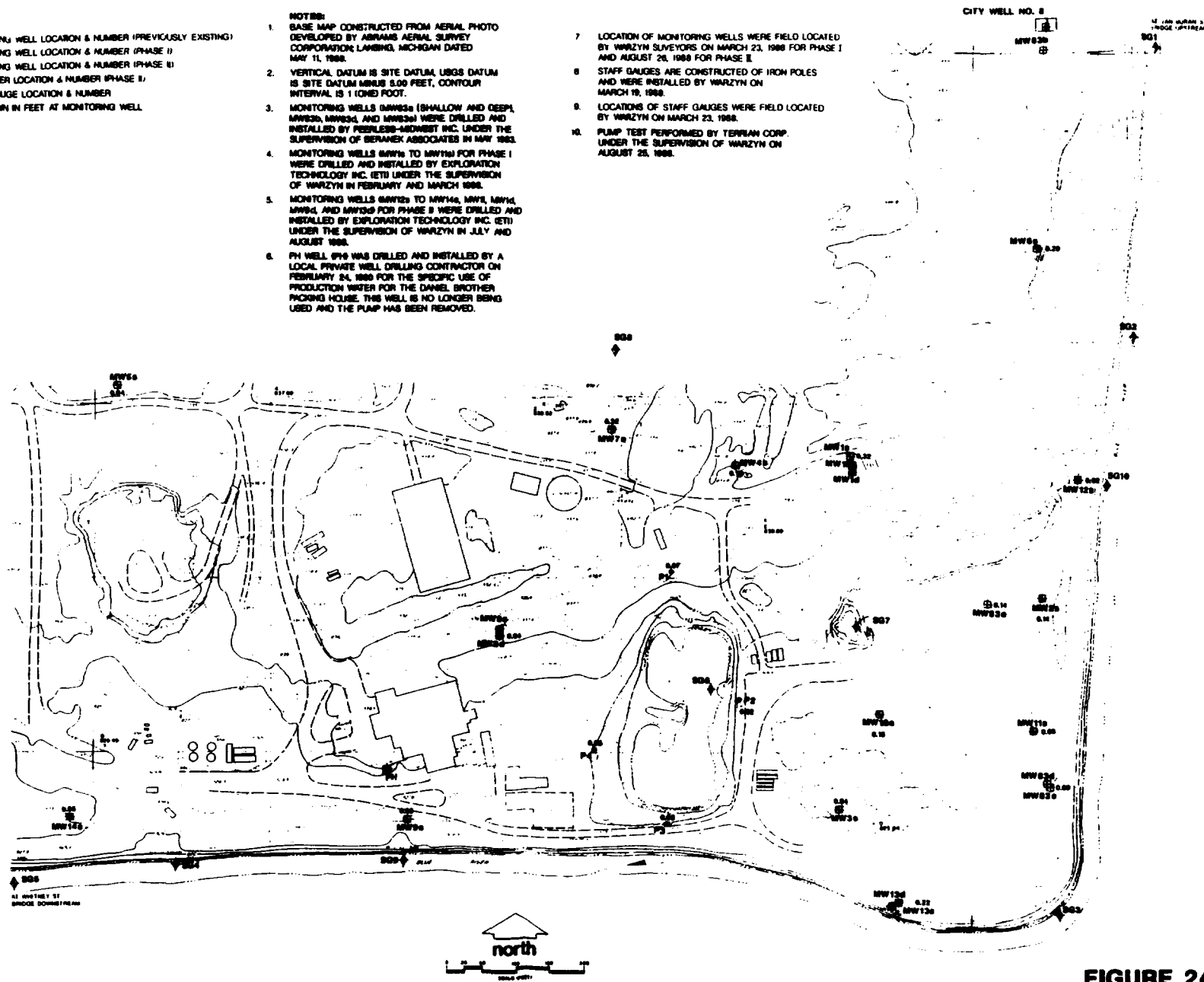
FIGURE 23



- LEGEND**
- MW53a (S) MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)
 - MW7a (S) MONITORING WELL LOCATION & NUMBER (PHASE I)
 - MW12a (S) MONITORING WELL LOCATION & NUMBER (PHASE II)
 - P-6 REZOMETER LOCATION & NUMBER (PHASE I)
 - SG-4 STAFF GAUGE LOCATION & NUMBER
 - 0.00 (S) DRAWDOWN IN FEET AT MONITORING WELL

- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ARMAAS AERIAL SURVEY CORPORATION; LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1' (ONE FOOT).
 3. MONITORING WELLS MW53a (SHALLOW AND DEEP), MW53b, MW53c, AND MW53d WERE DRILLED AND INSTALLED BY PERLESS-MORRIST INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1988.
 4. MONITORING WELLS MW7a TO MW7d FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS MW12a TO MW12d, MW13a, MW13b, MW13c, AND MW13d FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. PH WELL #14 WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1988 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.

7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 19, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.
10. PUMP TEST PERFORMED BY TERRAN CORP. UNDER THE SUPERVISION OF WARZYN ON AUGUST 25, 1988.



NOTES:

1. THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA SHOWN ON THE SECTION WERE DETERMINED FROM AND BASED UPON THE DATA FROM THE BORINGS AND TESTS. THE DEPTH OF THE TOP OF THE UPPER AQUIFER IS THE DEPTH OF THE FIRST SANDY OR SILTY SAND LAYER. THE DEPTH OF THE TOP OF THE LOWER AQUIFER IS THE DEPTH OF THE FIRST SANDY OR SILTY SAND LAYER. THE DEPTH OF THE TOP OF THE LOWER AQUIFER IS THE DEPTH OF THE FIRST SANDY OR SILTY SAND LAYER.
2. THE BORING LOGS AND RELATED INFORMATION REFLECT THE RESULTS OF THE BORINGS ONLY AT THE SPECIFIC LOCATIONS AND DEPTHS SHOWN. THE LOGS DO NOT REPRESENT THE ENTIRE SECTION. THE LOGS DO NOT REPRESENT THE ENTIRE SECTION. THE LOGS DO NOT REPRESENT THE ENTIRE SECTION.
3. FOR LOCATION OF CROSS SECTION, SEE FIGURE 14.
4. VERTICAL EXAGGERATION IS 10:1.
5. FOR GENERAL NOTES AND LEGEND, SEE FIGURE 14.

LEGEND

- FILL
- TOP SOIL
- LEAN CLAY (CL)
- SANDY LEAN CLAY (SC)
- SILTY CLAY (CL-ML)
- SILT (ML)
- SANDY SILT (SM-ML)
- SILTY SAND (SM)
- CLAYEY GRAVEL (GC)
- SAND (SP)
- GRAVEL (GP)

— 815.0 — POTENTIOMETRIC CONTOUR LINE

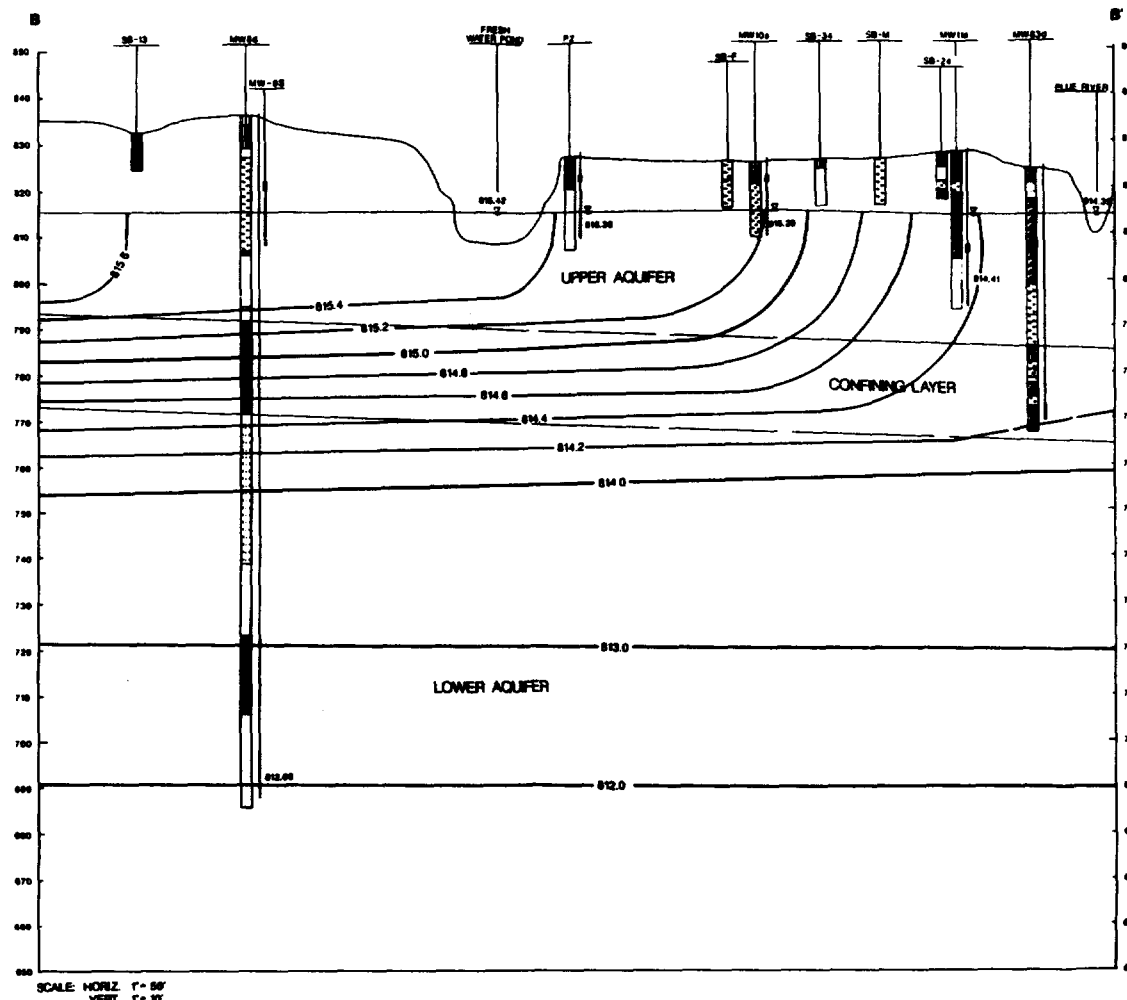
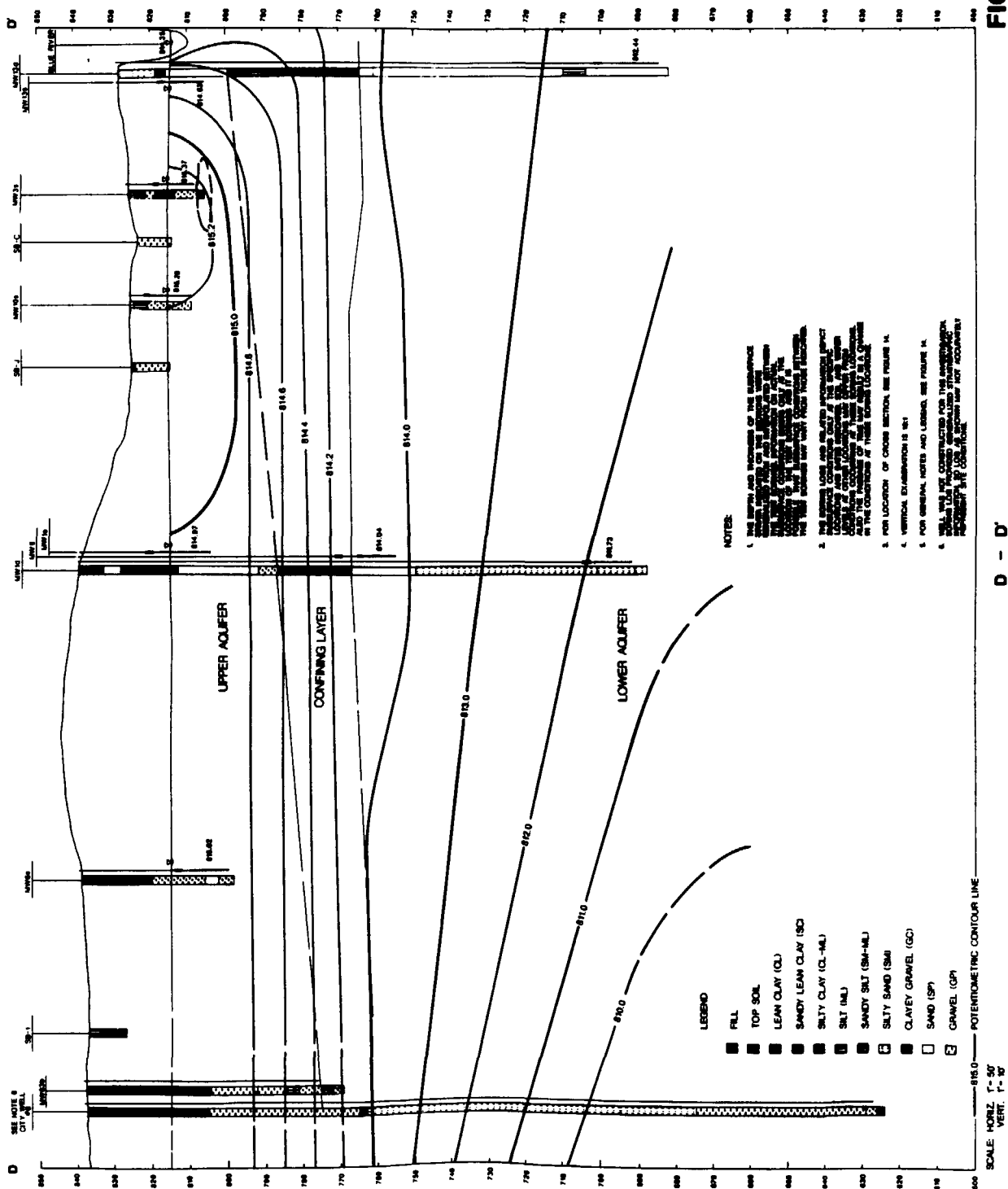


FIGURE 25



<input checked="" type="checkbox"/>	FILL
<input checked="" type="checkbox"/>	TOP SOIL
<input checked="" type="checkbox"/>	LEAN CLAY (CL)
<input checked="" type="checkbox"/>	SANDY LEAN CL.
<input checked="" type="checkbox"/>	SILTY CLAY (CL-S)
<input type="checkbox"/>	SILT (ML)
<input checked="" type="checkbox"/>	SANDY SILT (SM)
<input checked="" type="checkbox"/>	SILTY SAND (SM-S)
<input checked="" type="checkbox"/>	CLAYEY GRAVEL
<input type="checkbox"/>	SAND (SP)
<input checked="" type="checkbox"/>	GRAVEL (GP)

٥
 -
 ٥



WRR Site, Regional Gradient in Lower Aquifer

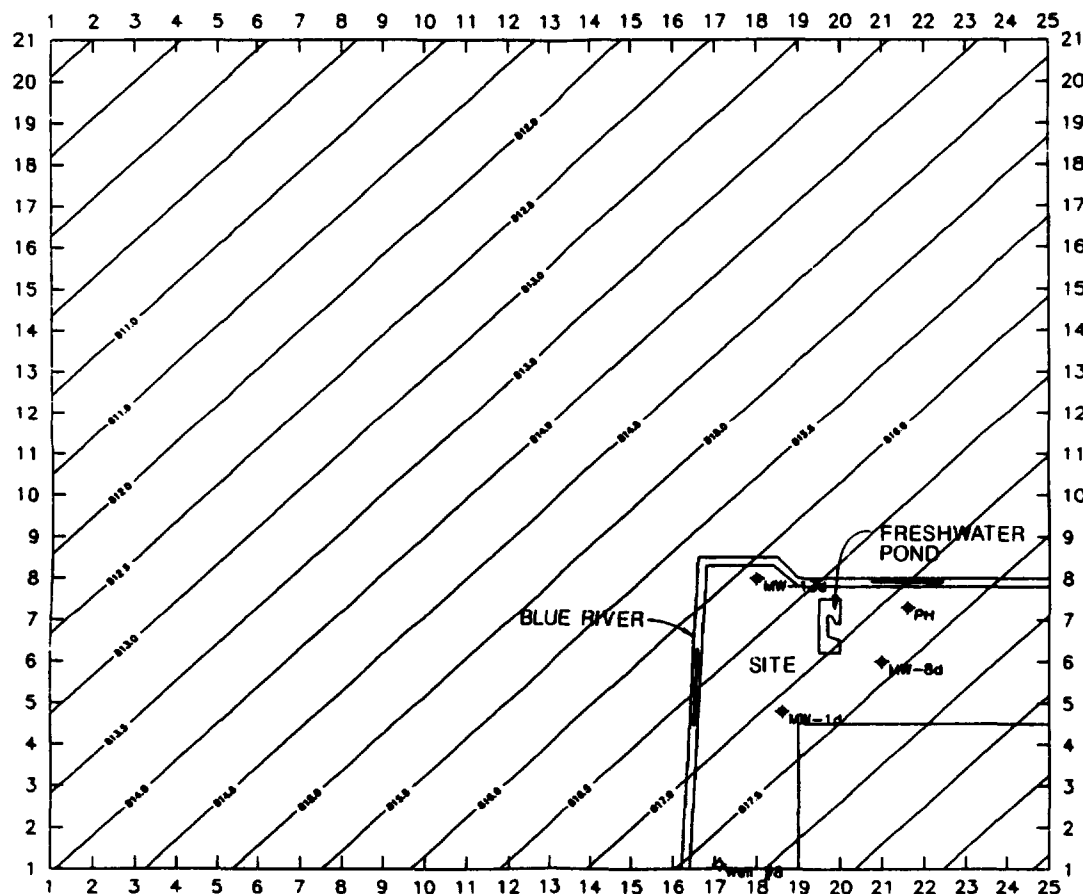


FIGURE 29

Modeled Regional Gradient without Dumping Effects Wayne Reclamation and Recycling R/W/S Columbia City, Indiana		Prepared by: P.J.V. Checked by: D.L.L. Date: 5/18/97
Warzyn Environmental Engineering, Inc. 1001 N. Main Street Columbia City, IN 46728		Date: 5/18/97 Drawn by: [Signature] Scale: [Blank]
OF 00128.04		[Blank]

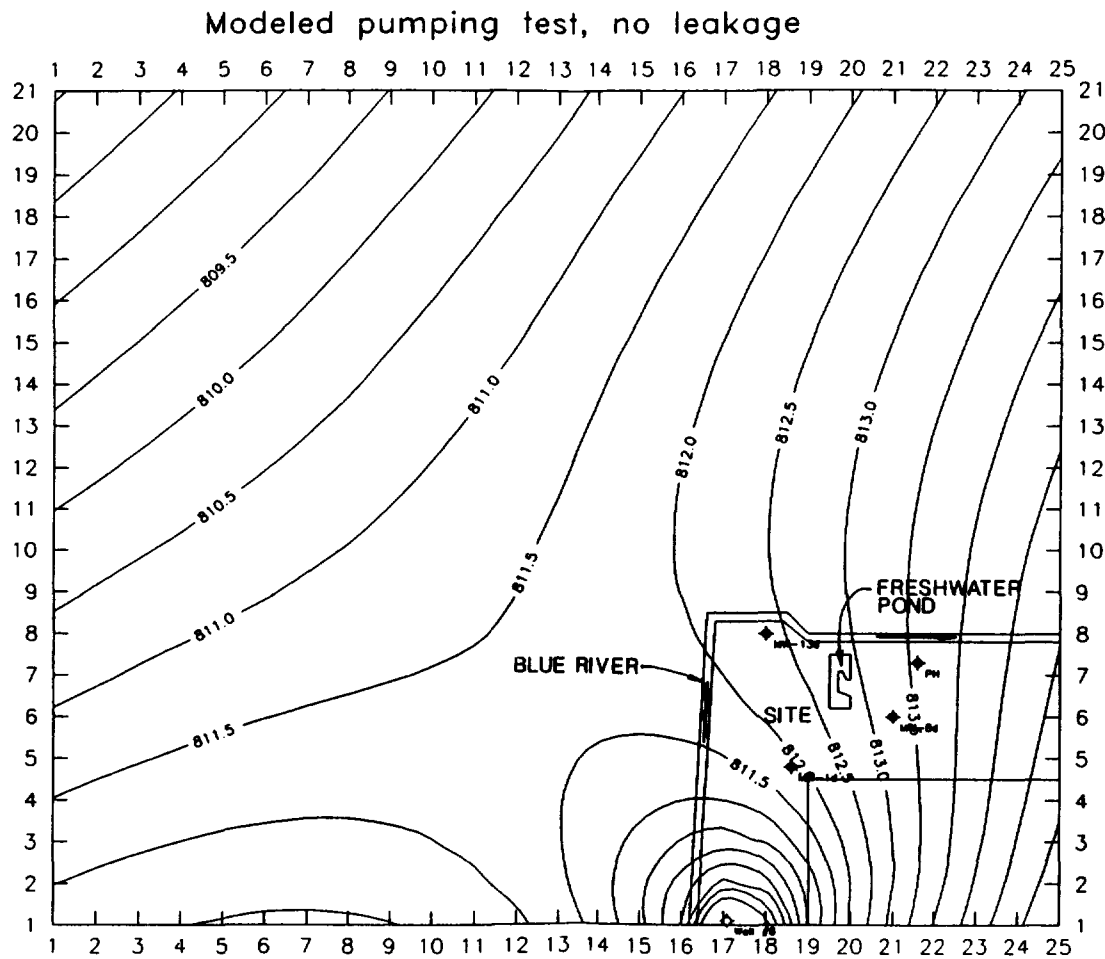


FIGURE 30

Prepared by: PJV Checked by: D.L.L. Date: 5/14/19	
Approved by: <i>[Signature]</i> Date: 5/14/19	
WARREN WAYNE RECLAMATION AND RECYCLING R/W'S COLUMBIA CITY, INDIANA	
OF 80128.04	

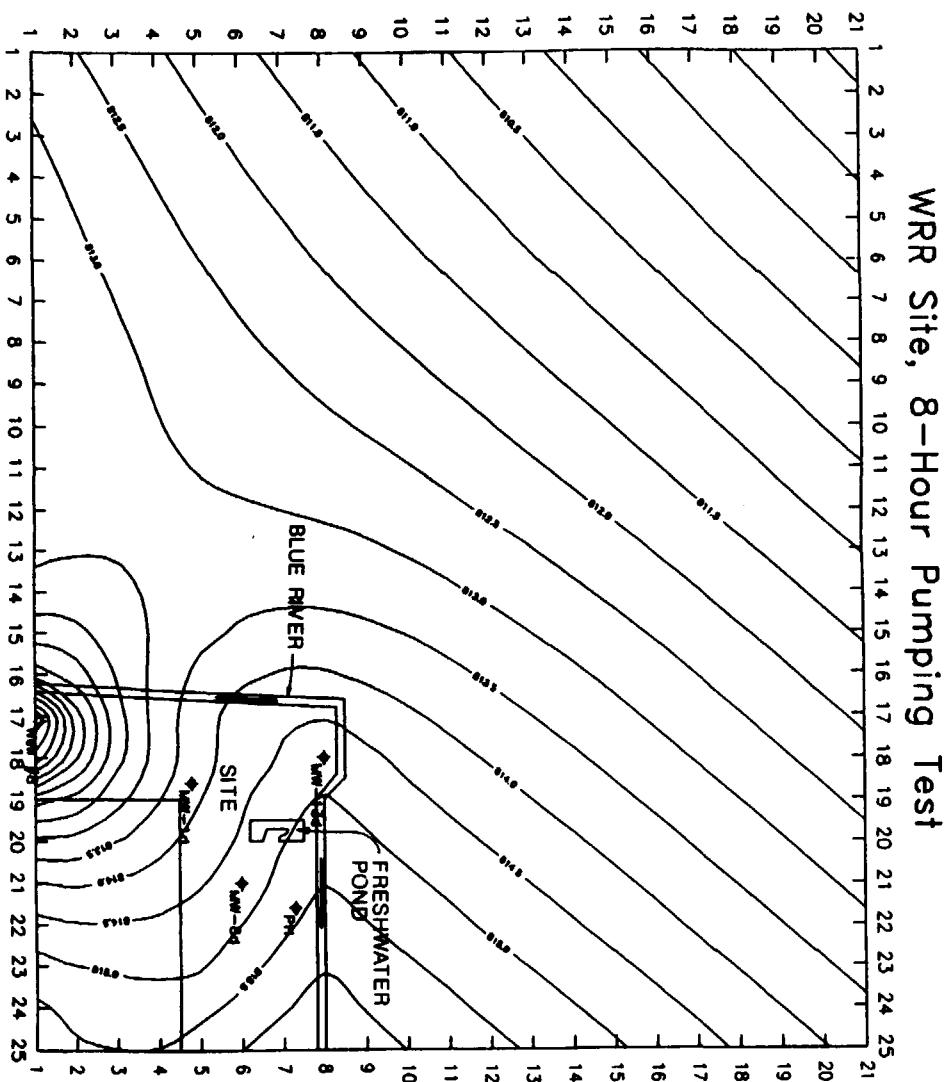


FIGURE 31

	GROUNDWATER MODELING RESULTS OF AQUIFER DURING PUMPING TEST WITH SIMULATION OF LEAKAGE AND PERMEABILITY CHANGES	WARZYN <small>ENGINEERING, INC.</small> <small>Madison • Indianapolis • Chicago • Detroit</small>	Designed By <u>PJV</u> Drawn By <u>D.L.L.</u> Checked By <u>TJM</u> Approved By <u>[Signature]</u> Date <u>5/14/99</u> Scale <u>1" = 100'</u>	Wayne Reclamation and Recycling RI/F8 COLUMBIA CITY, INDIANA
	60128.04			
	OF			
	1			

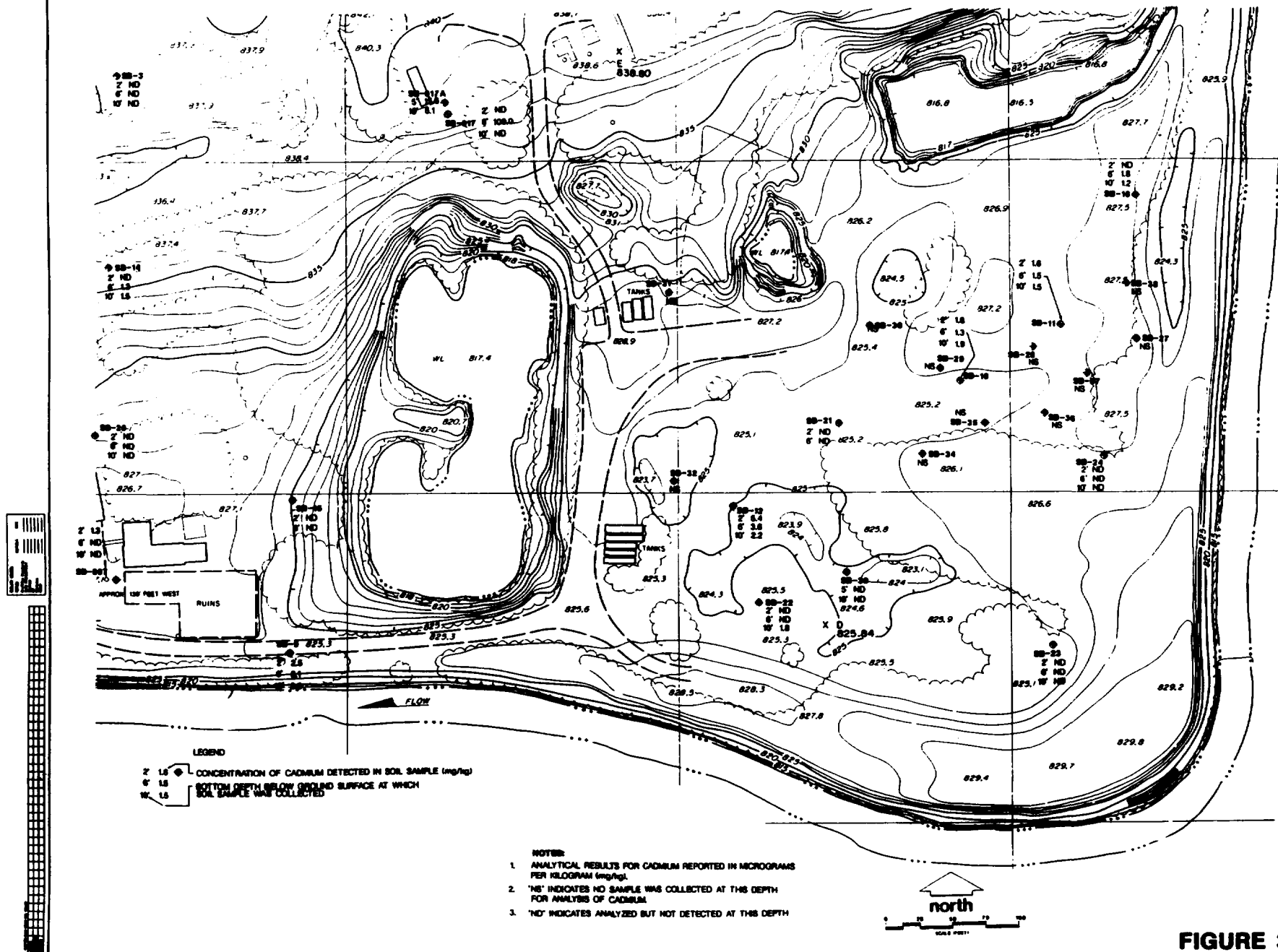
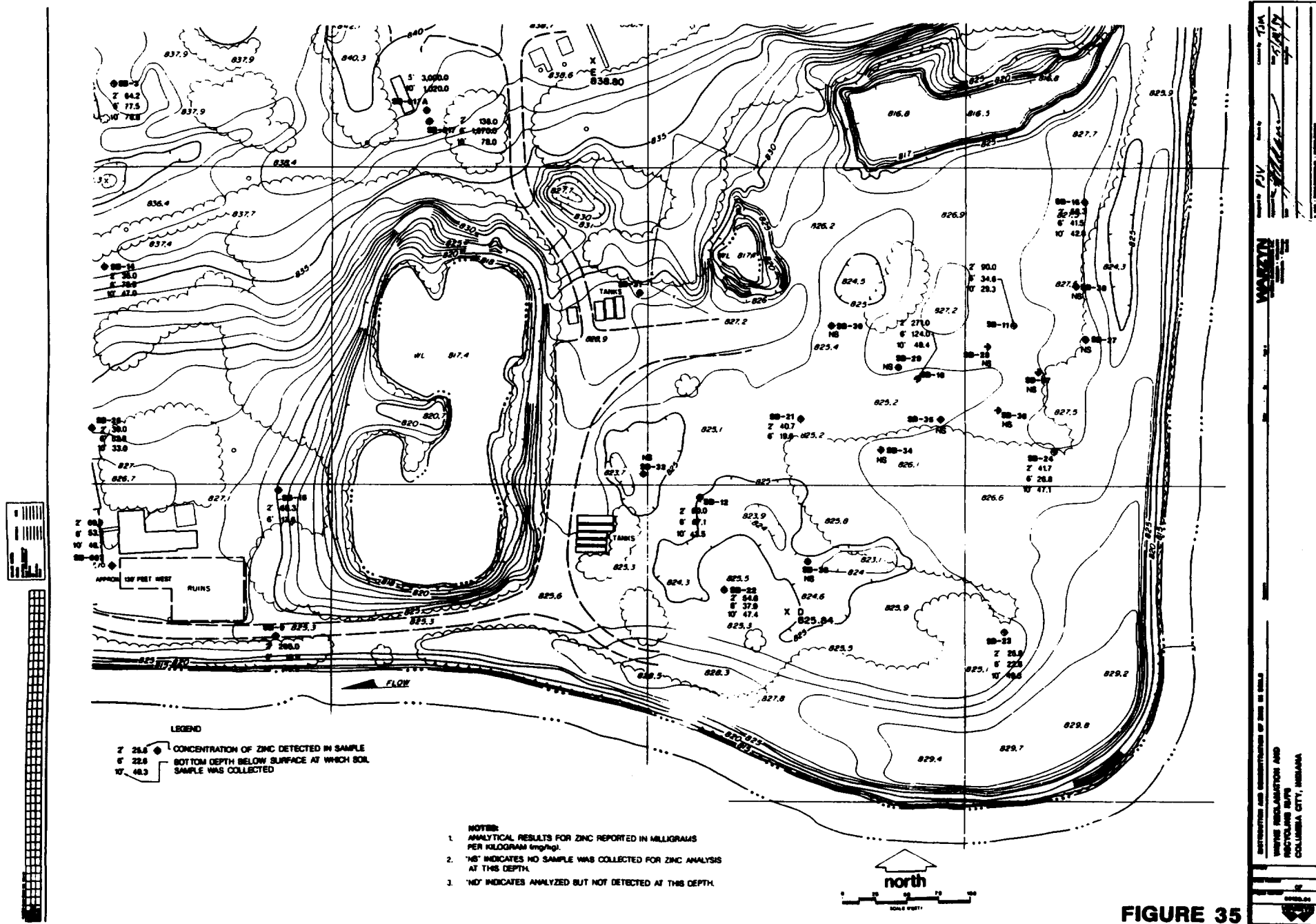


FIGURE 34



LEGEND

MW83a-⊙ MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)

MW7a-⊙ MONITORING WELL LOCATION & NUMBER (PHASE I)

MW12a-⊙ MONITORING WELL LOCATION & NUMBER (PHASE II)

P4-⊙ PIEZOMETER LOCATION & NUMBER (PHASE II)

SG4-⬥ STAFF GAUGE LOCATION & NUMBER

29.0-⊙ CONCENTRATION OF TOTAL CHLORINATED ETHENES IN MICROGRAMS PER LITER (ug/l)

37.0-⊙

INDICATES SAMPLING ROUND:
 'I' PHASE I SAMPLING (FEB. - MAR. 1988)
 'II' PHASE II SAMPLING (AUG. - SEPT. 1988)

- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, USGS DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. MONITORING WELLS (MW83a) [SHALLOW AND DEEP], MW83b, MW83c, AND MW83d WERE DRILLED AND INSTALLED BY PEERLESS-MIDWEST INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1983.
 4. MONITORING WELLS (MW1a TO MW11a) FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS (MW12a TO MW14a, MW1, MW1d, MW8d, AND MW13d) FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. PH WELL (P4) WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1980 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.

7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SUVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 26, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 19, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.
10. ANALYTICAL RESULTS FOR TOTAL CHLORINATED ETHENES IN GROUNDWATER SAMPLES REPORTED IN MICROGRAMS PER LITER (ug/l).
11. 'NS' INDICATES NO SAMPLE WAS COLLECTED FOR VOLATILE ORGANICS ANALYSIS.
12. 'ND' INDICATES ANALYZED BUT NOT DETECTED.

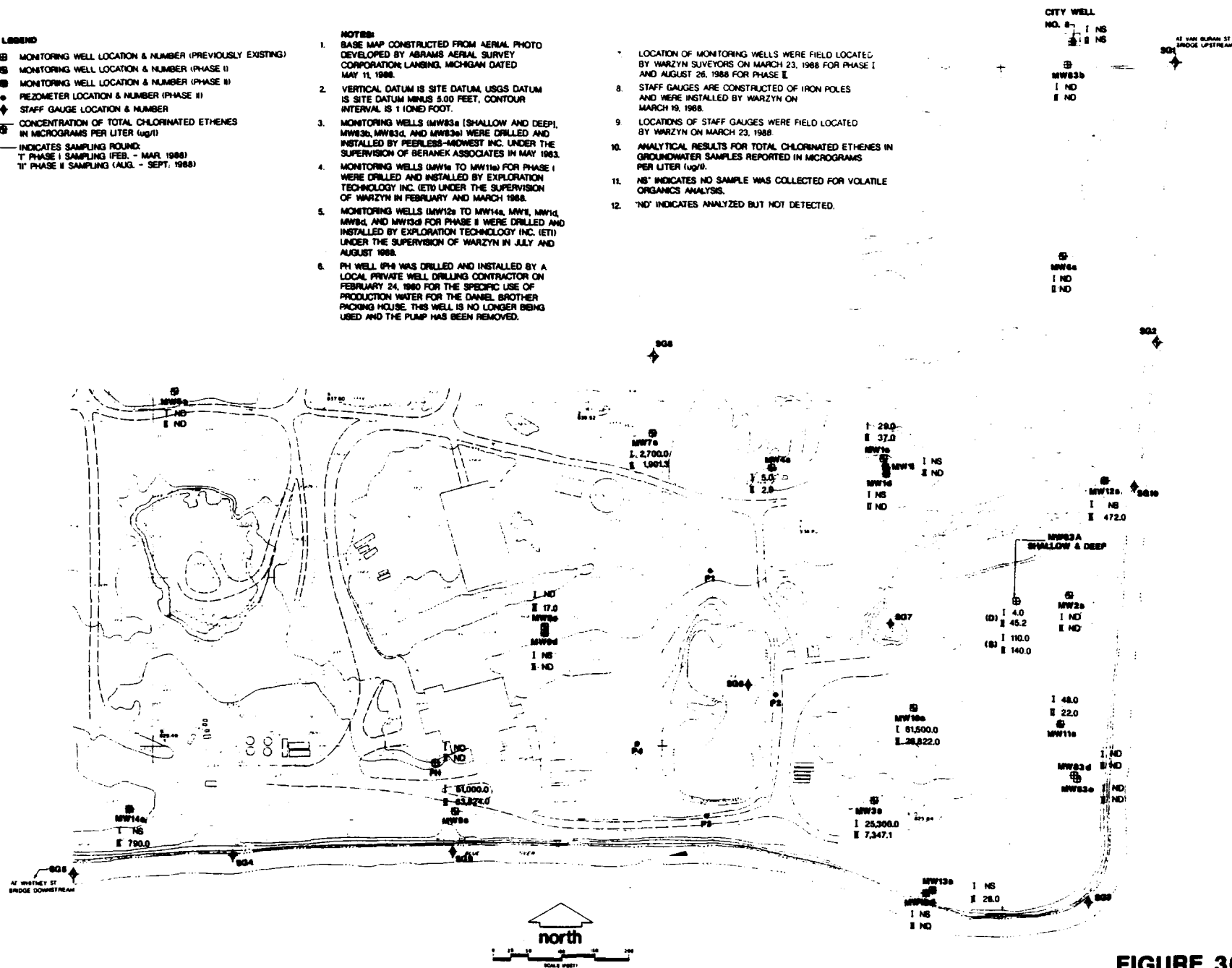
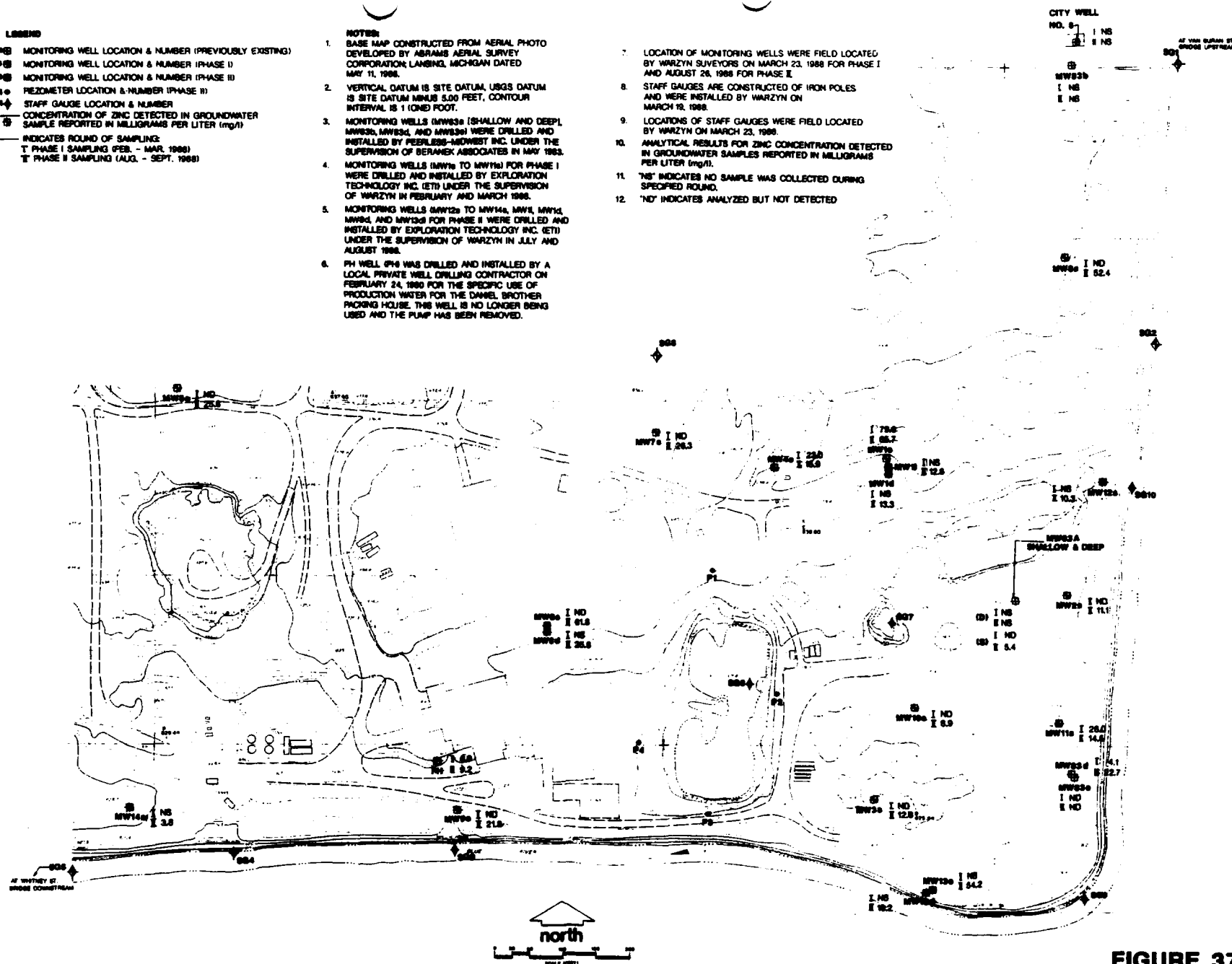


FIGURE 36

- LEGEND**
- MW334-4 MONITORING WELL LOCATION & NUMBER (PREVIOUSLY EXISTING)
 - MW74-6 MONITORING WELL LOCATION & NUMBER (PHASE I)
 - MW124-6 MONITORING WELL LOCATION & NUMBER (PHASE II)
 - P4-6 REZOMETER LOCATION & NUMBER (PHASE II)
 - SG4-6 STAFF GAUGE LOCATION & NUMBER
 - 28.0 CONCENTRATION OF ZINC DETECTED IN GROUNDWATER SAMPLE REPORTED IN MILLIGRAMS PER LITER (mg/l)
 - 14.5 INDICATES ROUND OF SAMPLING:
T PHASE I SAMPLING (FEB. - MAR. 1988)
I PHASE II SAMPLING (AUG. - SEPT. 1988)

- NOTES**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM. USGS DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. MONITORING WELLS (MW334) (SHALLOW AND DEEP), MW335, MW336, AND MW337 WERE DRILLED AND INSTALLED BY PERLESS-MIDWEST INC. UNDER THE SUPERVISION OF BERANEK ASSOCIATES IN MAY 1983.
 4. MONITORING WELLS (MW14 TO MW16) FOR PHASE I WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN FEBRUARY AND MARCH 1988.
 5. MONITORING WELLS (MW124 TO MW146, MW18, MW19, MW20, AND MW21) FOR PHASE II WERE DRILLED AND INSTALLED BY EXPLORATION TECHNOLOGY INC. (ETI) UNDER THE SUPERVISION OF WARZYN IN JULY AND AUGUST 1988.
 6. PH WELL #4 WAS DRILLED AND INSTALLED BY A LOCAL PRIVATE WELL DRILLING CONTRACTOR ON FEBRUARY 24, 1989 FOR THE SPECIFIC USE OF PRODUCTION WATER FOR THE DANIEL BROTHER PACKING HOUSE. THIS WELL IS NO LONGER BEING USED AND THE PUMP HAS BEEN REMOVED.

7. LOCATION OF MONITORING WELLS WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988 FOR PHASE I AND AUGUST 24, 1988 FOR PHASE II.
8. STAFF GAUGES ARE CONSTRUCTED OF IRON POLES AND WERE INSTALLED BY WARZYN ON MARCH 18, 1988.
9. LOCATIONS OF STAFF GAUGES WERE FIELD LOCATED BY WARZYN ON MARCH 23, 1988.
10. ANALYTICAL RESULTS FOR ZINC CONCENTRATION DETECTED IN GROUNDWATER SAMPLES REPORTED IN MILLIGRAMS PER LITER (mg/l).
11. "NS" INDICATES NO SAMPLE WAS COLLECTED DURING SPECIFIED ROUND.
12. "ND" INDICATES ANALYZED BUT NOT DETECTED.



LEGEND

SW7 ▲ SURFACE WATER AND SEDIMENT SAMPLING LOCATION & NUMBER (PHASE I)

S 37.0 — CONCENTRATION OF TOTAL CHLORINATED ETHENES DETECTED IN SAMPLE

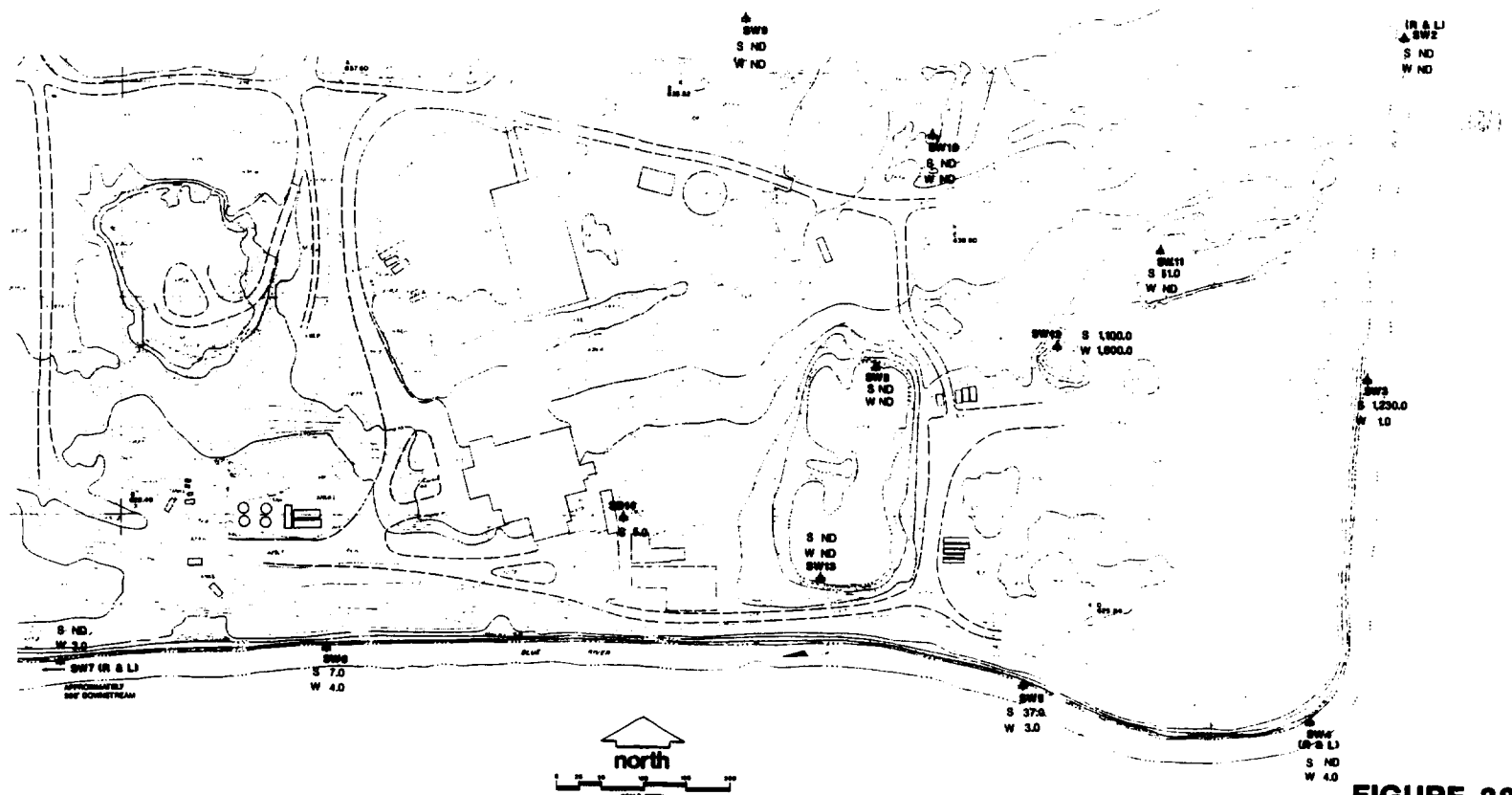
W 3.0 —

INDICATES SAMPLE TYPE:

"S" SEDIMENT SAMPLE, RESULT REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)

"W" SURFACE WATER SAMPLE, RESULT REPORTED IN MICROGRAMS PER LITER (ug/l)

- NOTES:**
1. BASE MAP CONSTRUCTED FROM AERIAL PHOTO DEVELOPED BY ABRAMS AERIAL SURVEY CORPORATION, LANSING, MICHIGAN DATED MAY 11, 1988.
 2. VERTICAL DATUM IS SITE DATUM, UGDS DATUM IS SITE DATUM MINUS 5.00 FEET, CONTOUR INTERVAL IS 1 (ONE) FOOT.
 3. SURFACE WATER AND SEDIMENT SAMPLES WERE COLLECTED BY WARZYN ON MARCH 17 & 18, 1988.
 4. LOCATION OF SURFACE WATER AND SEDIMENT SAMPLES WERE FIELD LOCATED BY WARZYN SURVEYORS ON MARCH 23, 1988.
 5. SEDIMENT SAMPLES WERE COLLECTED FROM BOTH BANKS OF THE BLUE RIVER AT LOCATIONS MARKED (R & L). THE LEFT BANK WOULD BE AS IF YOU ARE LOOKING UPSTREAM.
 6. SD14 WAS COLLECTED IN A SURFACE WATER RUNOFF PATHWAY. NO STANDING WATER WAS PRESENT.
 7. "NS" INDICATES NO SAMPLE WAS COLLECTED FOR SAMPLING LOCATION.
 8. ALL SURFACE WATER AND SEDIMENT SAMPLES COLLECTED DURING PHASE I ONLY.
 9. "ND" INDICATES ANALYZED BUT NOT DETECTED.



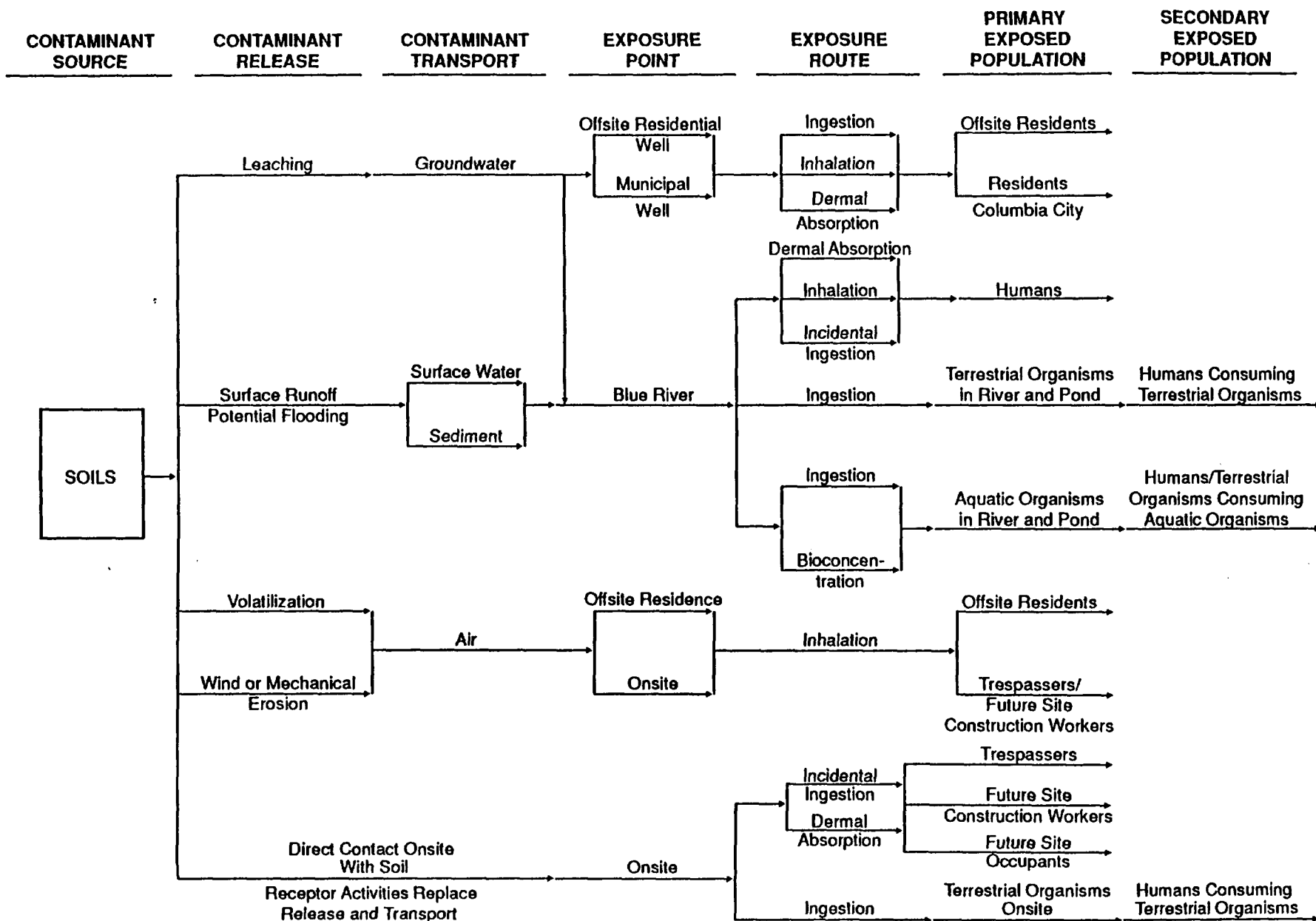
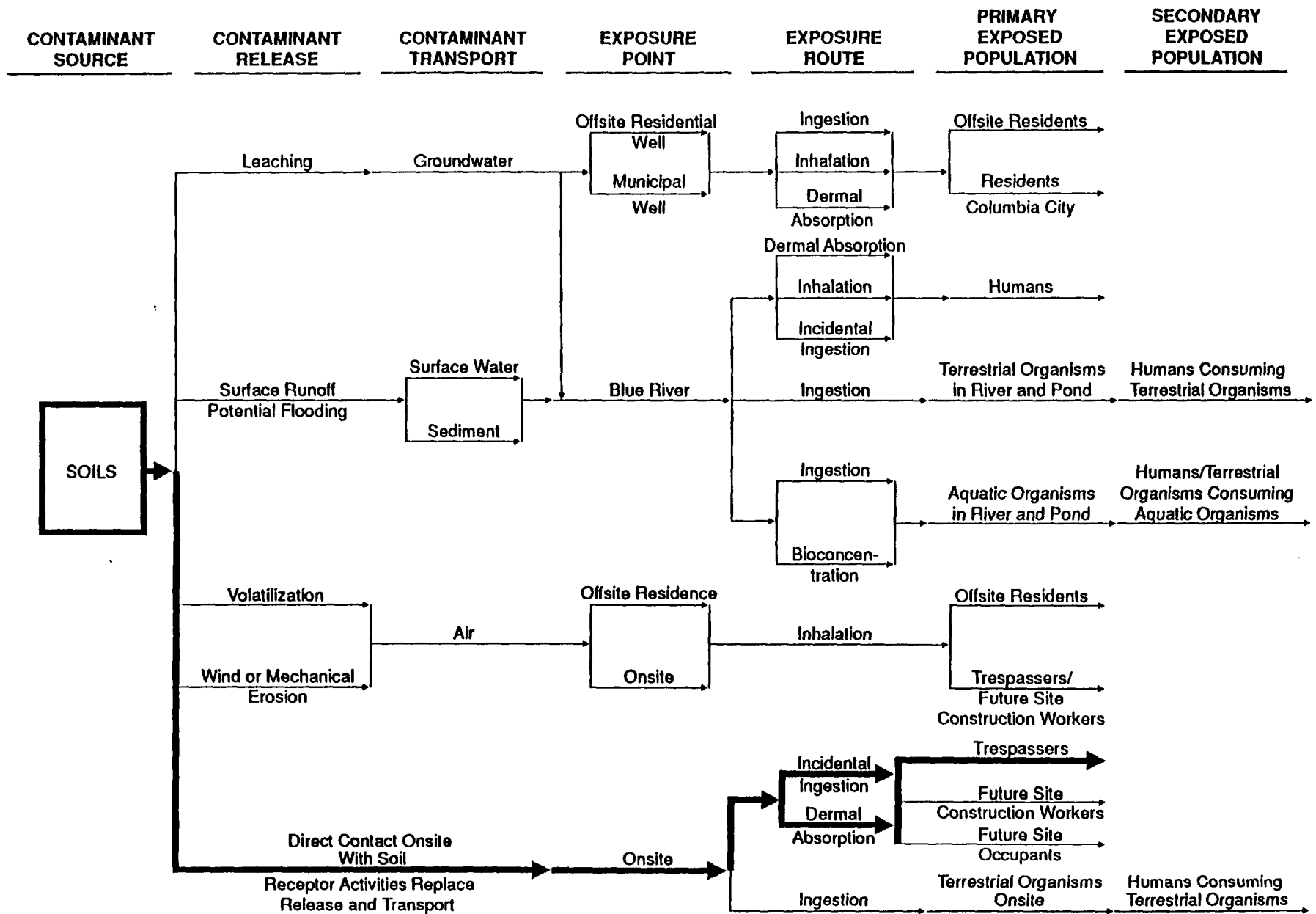
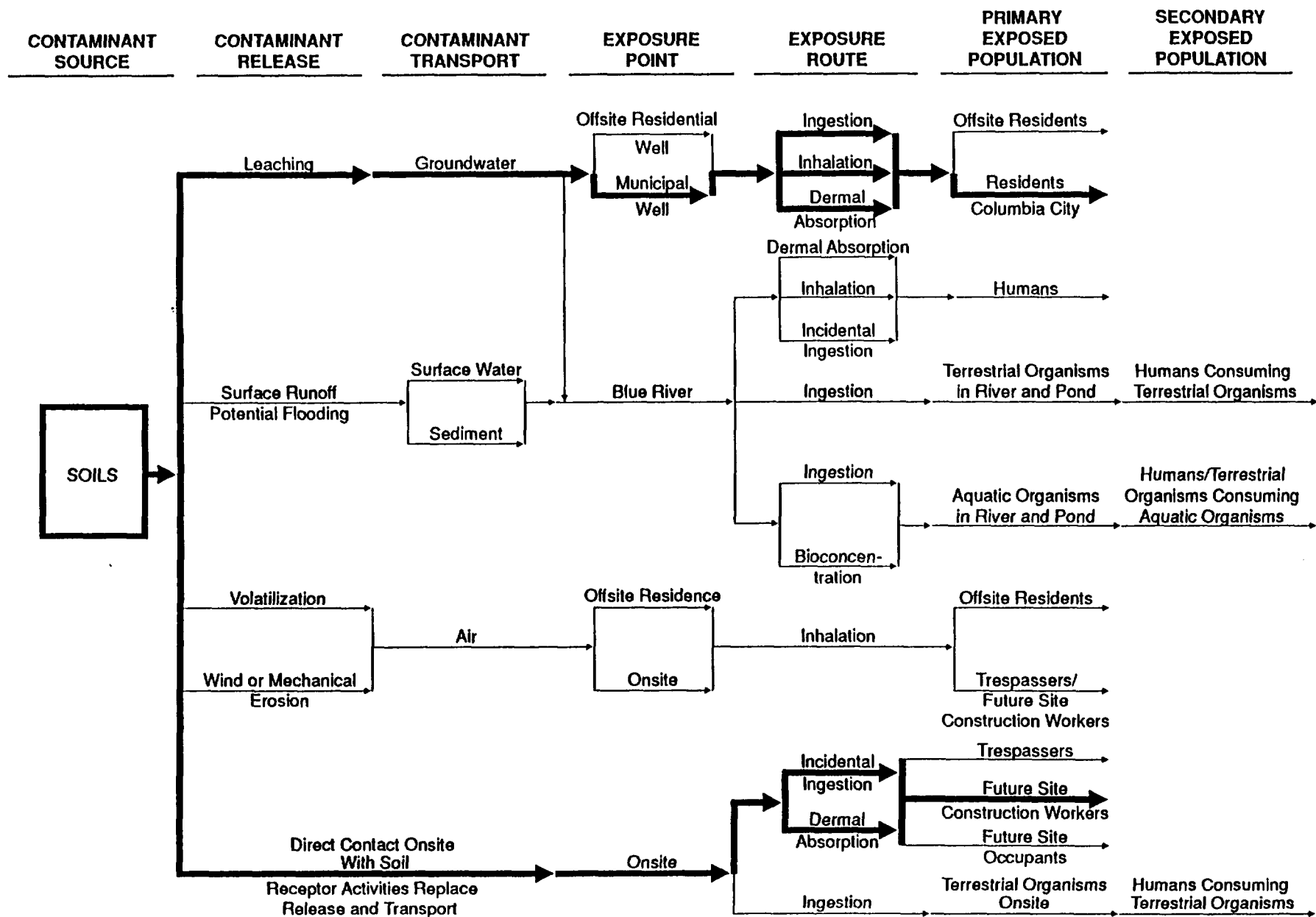


FIGURE 39
POTENTIAL EXPOSURE PATHWAYS
 WAYNE RECLAMATION AND RECYCLING SITE



Pathways of greatest concern are in bold.

FIGURE 40
POTENTIAL EXPOSURE PATHWAYS - CURRENT SITE CONDITIONS
WAYNE RECLAMATION AND RECYCLING SITE



Pathways of greatest concern are in bold.

FIGURE 41
POTENTIAL EXPOSURE PATHWAYS - FUTURE SITE CONDITIONS
 WAYNE RECLAMATION AND RECYCLING SITE

Table 1. Summary of Key Dates and Events at the Wayne Reclamation and Recycling, Inc. Site

<u>Approximate Date of Event</u>	<u>Event or Action</u>
1826 - 1840	Whitley County surveyed
1830's	Seeks Indian Reservation acquired site land by treaty
1860's	Site deeded to Issac Whiteman for agricultural use
Late 1800's	Increased industry in Columbia City area
Early 1900's	Widdifield family acquired site land
1931	Daniels Brothers Meat Packing purchased portion of site land and operated a slaughterhouse
1937	Columbia City Well #6 installed
1953	City purchased 28 acres from Widdifields and began landfill operation
1959	City sold 2.7 acres to Holmes & Co. (lumber)
1965	Incinerator dedicated
Early 1960's	Wayne Waste Oil operating in Fort Wayne, Indiana; later incorporated as Wayne Reclamation & Recycling, Inc.
1970	City landfill closed
1972	Columbia City Well #7 installed for peak usage
1973	Daniels Brothers Meat Packing sold to Frederick Sallot who manufactured hardwood cradles and commercial handles
1975	City built water treatment facility and installed well #8
1975	Wayne Reclamation & Recycling, Inc. (WRR) incorporated; purchased 12 acres from Sallot, 13.6 acres from city; Indiana Pollution Control Board approved WRR liquid waste treatment facility
1976	WRR licensed to haul liquid industrial wastes

(Table continued next page)

Table 1 (continued). Summary of Key Dates and Events at the Wayne Reclamation and Recycling, Inc. Site

<u>Approximate Date of Event</u>	<u>Event or Action</u>
1979-1980	Waste Hauler Reports prepared by WRR state that 250,000 gallons of sludge hauled to Williams County Landfill, Bryan, OH. Landfill never received any waste.
1980	Indiana State Board of Health (ISBH) begins illegal dumping investigation and inspection of the WRR site
1982	WRR pleaded guilty to charge of filing false hauler reports and illegal "depositing of contaminants at the site"; fined \$1,000 for each and forced to pay for risk assessment and cleanup of the site
1982	WRR sold 6 acres of land to Holmes & Co.
1984	Beranek Associates, Inc. issue risk assessment for site
1986	Removal Consent Order
1986-87	Removal Cleanup
1987	RI/FS Consent Order
1988	CERCLA Section 106 unilateral Order
1988	Cleanup pursuant to Section 106 Order
1988	Phase I and Phase II RI

Table 2. Correspondence between Boring Logs and Monitoring Wells.

Soil Boring #	Monitoring Well #	Surface Elevation*	End of Boring Depth (feet)	Elevation*	Bottom of Upper Aquifer (feet) (elev)*
SB-001	MW-7S	837.7	10	827.7	
SB-002		838.2	31	807.2	
SB-002S		838.2	10	828.2	
SB-002E		838.3	10	828.3	
SB-002W		838.4	10	828.4	
SB-003		836.7	10	826.7	
SB-004		821.9	8	813.9	
SB-005	MW-9S	823.8	10	813.8	
SB-006		826.2	10	816.2	
SB-007		827.1	20	807.1	
SB-007N		828.1	10	818.1	
SB-007E		827.0	10	817.0	
SB-007W		827.7	10	817.7	
SB-008		829.5	10	819.5	
SB-009	MW-8S	825.5	10	815.5	44 792.3
SB-010		825.8	10	815.8	
SB-011		826.7	10	816.7	
SB-012		825.6	10	815.6	
SB-013		832.7	8	824.7	
SB-014		837.0	30	807.0	
	MW-8D	836.3	150	686.3	
SB-015	MW-2S	824.5	10	814.5	52 787.3
SB-016		827.0	23	804.0	
SB-017		838.6	10	828.6	
SB-017A		838.4	11.5	826.9	
SB-018		839.9	35	804.9	
	MW-1I	839.5	85	754.5	
	MW-1D	839.3	148.5	690.8	
SB-018A	MW-4S	839.4	10	829.4	
SB-019		840.5	37	803.5	
SB-020		838.8	40	798.8	
SB-021		825.5	16	809.5	
SB-022		825.8	20	805.8	
SB-023		826.2	10	816.2	
SB-024		827.3	10	817.3	
SB-025	MW-3S	834.6	25	809.6	
SB-026		835.9	10	825.9	
SB-027		827.4	10	817.4	
SB-028		826.4	10	816.4	
SB-029		825.9	10	815.9	
SB-030		824.7	10	814.7	
SB-031		828.9	10	818.9	
SB-032	MW-5S	824.4	10	814.4	
SB-033		824.6	10	814.6	

(Table continued on next page)

Table 2 (continued). Correspondence between Boring Logs and Monitoring Wells.

Soil Boring #	Monitoring Well #	Surface Elevation*	End of Boring Depth (feet)	Elevation*	Bottom of Upper Aquifer (feet) (elev)*
SB-034		826.1	10	816.1	
SB-035		825.5	10	815.5	
SB-036		826.1	10	816.1	
SB-037		827.3	10	817.3	
SB-038		826.9	10	816.9	
SB-039	(MW-12S)	824.6	60	764.6	27 797.6
SB-040	(MW-14S)	823.6	35	788.6	
SB-A		824.9	9	815.9	
SB-B		824.4	9	815.4	
SB-C		824.1	9	815.1	
SB-D		826.2	13	813.2	
SB-E		825.2	10	815.2	
SB-F		825.5	10	815.5	
SB-G		825.6	10	815.6	
SB-H		826.9	10	816.9	
SB-I		828.6	10	818.6	
SB-J		825.4	10	815.4	
SB-K		825.5	10	815.5	
SB-L		825.1	10	815.1	
SB-M		826.3	10	816.3	
SB-N		826.5	10	816.5	
SB-O		826.4	10	816.4	
SB-P		826.8	10	816.8	
SB-Q		826.5	10	816.5	
SB-R		827.4	10	817.4	
SB-S		827.7	10	817.7	
SB-T		824.5	10	814.5	
SB-U		827.7	10	817.7	
SB-V		825.1	10	815.1	
	MW-11S	827.4	34	793.4	
	MW-12S	825.6	19.5	806.1	
	MW-13D	828.3	145	683.3	37.5 790.8
	MW-13S	828.3	25	803.3	
	MW-14S	823.6	18.9	804.7	
	P1	836.1	27	809.1	
	P2	826.9	18	808.9	
	P3	825.3	20	805.3	
	P4	824.6	15	809.6	

* Elevations referenced to site datum. To convert to USGS (amsl) subtract 5.00 ft

Table 3. Summary of Laboratory Soil Analysis

Hydrogeological Unit	Depth (ft)	Elevation	Boring/Well Number	Sample Number	Material Description (USCS)	Atterburg Limits		Wet Sieve		Hydrometer	
						LL	PI	% Gr	% Sand	% Silt	% Clay
Vadose Zone	3	822.8	SB-022/MW-3S	2	Gray Clayey Fine-Coarse SAND, Some Silt (SC)	39	21	0	52.9	27.4	19.7
Vadose Zone	19	821.5	SB-019/MW-4S	7	Brown Silty CLAY, Some Sand, Trace Gravel (CL-ML)	19	5	1.3	27.1	50.9	20.7
Upper Aquifer	39	800.5	MW-1D	2	Brown Fine-Medium SAND, Little Silt and Clay (SP-SM)	-	-	0	88.9	11.0	
Upper Aquifer	24	810.6	SB-025/MW-5S	8	Brown Fine-Coarse SAND, Some Gravel, Little Silt, Trace Clay (SP-SM)	-	-	13.4	77.7	6.1	2.9
Upper Aquifer	14	811.5	SB-021/MW-10	6	Brown Fine-Coarse SAND, Some Gravel, Trace Silt and Clay (SP-SM)	-	-	15.6	78.4	3.7	2.3
Confining Layer	59	780.5	MW-1D	6	Brown Sandy SILT, Some Clay, Little Gravel (ML)	15	3	6.9	35.6	38.6	18.9
Confining Layer	59	777.3	MW-8D	5	Brown Sandy SILT, Some Clay, Trace Gravel (ML)	13	2	2.8	45.3	34.1	17.7
Confining Layer	49	779.3	MW-13D	5	Brown Silty CLAY, Some Sand Trace Gravel (CL-ML)	18	5	3.4	32.6	43.2	20.8
Confining Layer	89	739.3	MW-13D	13	Brown SILT, Some Clay, Trace Sand (ML)	-	-	0	3.2	75.6	21.2
Lower Aquifer	134	705.3	MW-1D	10	Brown Fine-Coarse SAND, Some Gravel, Silt and Clay (SM)	-	-	14.4	70	15.7	
Lower Aquifer	139	689.3	MW-13D	23	Brown Fine-Coarse SAND, Some Gravel, Silt and Clay (SP)	-	-	23.8	51.2	25.0	
Lower Aquifer	149	687.3	MW-8D	18	Brown Fine SAND, Some Silt and Clay (SM)	-	-	0	84.8	15.2	

Notes:LL - Liquid Limit (The water content of the sample when it has a shear strength of 1 g/cm²)

PL - Plastic Limit (The range in water content between the liquid limit and the plastic limit)

Wet Sieve (Test performed to measure percent of silt and clay in the sample)

Hydrometer (Test performed to measure percent of gravel and sand in the sample)

* Elevations referenced to site datum. To convert to USGS (amsl) subtract 5.00 ft

Table 4. Summary of Water Level Data.

Level Location	Top of * Inner Casing										Pumping Test		AVERAGE	S.D.
		03-May 1988	03-Aug 1988	08-Aug 1988	09-Aug 1988	10-Aug 1988	11-Aug 1988	13-Aug 1988	24-Aug 1988	25-Aug 1988				
MW-10	841.73						822.46	813.80	811.73	816.39			816.10	4.03
MW-11	841.52		814.75	814.63	814.48	814.46	814.68	814.41	814.04	815.51			814.62	0.39
MW-1S	840.97	817.12	815.99	815.24	815.10	815.10	815.16	815.05	814.97	815.29			815.45	0.66
MW-2S	829.75	816.30	817.77	814.95	814.90	814.88	814.91	814.85	814.85	814.99			815.38	0.95
MW-3S	828.75	817.60	818.37	815.48	815.46	815.45	815.45	815.41	815.37	815.41			816.00	1.08
MW-4S	842.23	817.33	815.29	815.43	815.33	815.28	815.30	815.24	815.19	815.32			815.52	0.64
MW-5S	837.35	818.60	820.44	816.24	816.23		816.21	816.19	816.04	816.08			817.00	1.53
MW-6S	845.46	816.67	815.44	815.15	815.11		815.02	815.02	815.02	815.15			815.32	0.53
MW-7S	840.58	817.53	815.25	815.41	815.38	815.44	815.30	815.30	815.18	815.50			815.59	0.69
MW-8D	838.51								812.05	816.60			814.33	2.27
MW-8S	839.91	817.96	819.96	815.65	815.64	815.62	815.61	814.59	815.49	815.53			816.23	1.57
PH	831.03		815.32	812.58	814.64			814.79	812.12	816.65			814.35	1.56
MW-9S	829.92	817.97	819.95	815.69	815.69		815.66	815.65	815.53	815.56			816.46	1.53
MW-10S	827.43	817.28	814.74	815.28	815.24	815.22	815.23	815.18	815.20	815.35			815.41	0.68
MW-11S	829.49	816.19	814.83	814.70	814.62	814.76	814.70	814.57	814.41	815.09			814.87	0.50
MW-12S	827.18		815.06	814.96	814.94	814.90	814.94	814.87	814.94	814.96			814.95	0.05
MW-13D	830.49			814.76	813.36	814.50	813.19	813.79	812.44	815.59			813.95	0.99
MW-13S	831.18		816.27	814.70	814.66	814.72	814.66	814.63	814.63	814.85			814.89	0.53
MW-14S	825.76		815.52	814.85	814.82	814.83	814.83	814.81	814.81	814.86			814.92	0.23
P-1	838.64		815.41	815.39	815.32	815.39	815.39	815.45	815.29	815.36			815.38	0.05
P-2	829.91		815.60	815.26	815.51	815.43	815.43	816.38	815.36	815.38			815.54	0.33
P-3	827.98		815.00	815.49	815.49	815.43	815.48	815.40	815.36	815.42			815.38	0.15
P-4	827.13		814.18	815.55	815.54	815.55	815.52	815.49	815.43	815.48			815.34	0.44
83D (D)	829.61		815.12	814.86	814.74	814.63	814.70	814.65		814.84			814.79	0.16
83E (S)	829.70		817.12	814.53	814.54	814.56	814.51	814.53	814.41	815.21			814.93	0.86
83A (D)	828.88		810.55	810.90	810.96	811.02	811.07	811.17	811.68	811.68			811.13	0.36
83A (S)	828.85		815.46	815.01	814.97	814.95	814.98	814.90	814.90	815.04			815.03	0.17
83B	838.48		804.09	804.47	804.46		804.66	804.78					804.49	0.23
SG-1	837.17	816.92			816.62		816.43	816.67					816.66	0.20
SG-2														
SG-3 (bend)	818.29			814.64	814.70	814.66	814.66	814.64	814.35	814.36			814.57	0.14
SG-4														
SG-5	834.54	815.49			815.43		815.46	815.36					815.46	0.03
SG-6 (fwp)	819.34	818.14		815.52	815.50	815.48	815.47	815.43	815.42	815.42			815.80	0.89
SG-7	820.21	820.21											820.21	0.00
SG-8	840.94	837.96		837.71	837.68	837.64	837.61	837.52					837.69	0.14
SG-9 (MW9)	819.48								814.16	814.16			814.16	
SG-10(MW12)	818.18								814.46	814.47			814.47	0.01

* Same note as Table 3

Table 5. Horizontal Gradient Calculations from West to East in the Upper Aquifer.

Location	WELLS		Separation Distance (feet)	May 3, 1988		August 25, 1988	
	From	To		Difference In Water Level (ft)	Horizontal Gradient (ft/ft)	Difference In Water Level (ft)	Horizontal Gradient (ft/ft)
Across Site	MW-5S	MW-6S	1325	1.93	0.0015	0.93	0.0007
East of Pond	MW-10S	MW-11S	215	1.09	0.0051	0.26	0.0012
West of Pond	MW-5S	MW-8S	555(1)	0.64	0.0012	0.55	0.0001

NOTE:

Water levels recorded in feet

(1) Distance corrected so change in distance is measured perpendicularly to equipotential lines.

Table 6. Slug Test Results for the Upper Aquifer.

<u>Test Location</u>	<u>Calculated Transmissivity (ft*ft/day)</u>	<u>Aquifer Thickness (feet)</u>	<u>Estimated Permeability (cm/sec) (ft/day)</u>	
MW-1S	3,813	27	5.0×10^{-2}	141
MW-2S	4,816	25	6.8×10^{-2}	193
MW-3S	318	6	1.9×10^{-2}	53
MW-4S	7,300	27	9.5×10^{-2}	270
MW-5S	2,961	25	4.2×10^{-2}	118
MW-6S	737	25	1.0×10^{-2}	29
MW-7S	6,628	27	8.7×10^{-2}	245
MW-8S	3,153	9	1.2×10^{-1}	350
MW-9S	20,863	20	3.7×10^{-1}	1,043
MW-10S	3,217	20	5.7×10^{-2}	161
<hr/>				
Geometric Mean:	3,249		6.0×10^{-2}	170
Minimum Value:	318		1.0×10^{-2}	29
Maximum Value:	20,863		3.7×10^{-1}	1,043

NOTES:

Aquifer test conducted by slug method.

Slug test analyzed by Bouwer & Rice Method (Bouwer & Rice, 1976).

Raw data and calculations included in Appendix G.

Table 7. Water Level Changes During Pumping Test.

WELL	TOC* Elevation	Aquifer Type	Water Elevations		Change During Test
			After 8 hrs Pumping	After Recovery	
MW-1D	841.73	confined	811.73	816.39	4.66
MW-1I	841.52	confined	814.04	815.51	1.47
MW-1S	840.97	confined	814.97	815.29	0.32
MW-2S	829.75	unconfined	814.85	814.99	0.14
MW-3S	828.75	confined	815.37	815.41	0.04
MW-4S	842.23	unconfined	815.19	815.32	0.13
MW-5S	837.35	variable	816.04	816.08	0.04
MW-6S	845.42	unconfined	815.02	815.15	0.13
MW-7S	840.58	variable	815.18	815.50	0.32
MW-8D	838.51	confined	812.05	816.60	4.55
MW-8S	839.91	unconfined	815.49	815.53	0.04
PH	831.03	confined	812.12	816.65	4.53
MW-9S	829.92	unconfined	815.53	815.56	0.03
MW-10S	827.43	unconfined	815.20	815.35	0.15
MW-11S	829.49	confined	814.41	815.09	0.68
MW-12S	827.18	unconfined	814.94	814.96	0.02
MW-13D	830.49	confined	812.44	815.59	3.15
MW-13S	831.18	unconfined	814.63	814.85	0.22
MW-14S	825.76	unconfined	814.81	814.86	0.05
P-1	838.64	confined	815.29	815.36	0.07
P-2	829.91	unconfined	815.36	815.38	0.02
P-3	827.98	confined	815.36	815.42	0.06
P-4	827.13	unconfined	815.43	815.48	0.05
83D(dp)	829.61	confined		814.84	
83E(sh)	829.70		814.41	815.21	0.80
83A(sh)	828.85		814.90	815.04	0.14
83A(dp)	828.88		811.68	811.68	.0
SG-3 (bend)	819.29	river	814.35	814.36	0.01
SG-6(fwp)	819.34	pond	815.42	815.42	.0
SG-9 (MW9)	819.48	river	814.16	814.16	.0
SG-10(MW12)	818.19	river	814.46	814.47	0.01

NOTE:

River Gradient from MW-12 = 0.00019 ft/ft

* Same note as Table 3

Table 8. Lower Aquifer Hydraulic Properties.

Observation Well	Calculated Transmissivity (ft ² /day)	Aquifer Thickness (feet)	Estimated Permeability (cm/sec) (ft/day)		Storativity (unitless)	Vertical Permeability (ft/day)	Test & Analysis Method
MW-1D	12,000	100	4.2x10 ⁻²	120	4.6x10 ⁻⁴	0.08	1
	17,000		6.0x10 ⁻²	170	3.9x10 ⁻²		2
MW-8D	12,000	100	4.2x10 ⁻²	120	5.1x10 ⁻⁴	0.03	1
	13,000		4.6x10 ⁻²	130	1.8x10 ⁻²		2
MW-13D	18,000	100	6.3x10 ⁻²	180	3.7x10 ⁻⁴	0.06	1
	25,000		8.8x10 ⁻²	250	3.2x10 ⁻²		2
PH Well	14,000	100	4.9x10 ⁻²	140	1.9x10 ⁻⁴	0.04	1
	17,000		5.6x10 ⁻²	160	1.8x10 ⁻²		2
<hr/>							
Geometric Mean:	14,000		4.8x10 ⁻²	140	3.6x10 ⁻⁴	0.05	1
Geometric Mean:	18,000		6.1x10 ⁻²	180	2.7x10 ⁻²		2

NOTES:

1. Pumping test data analyzed Log-log Curve Match Method (Lohman, 1972).
 2. Pumping test data analyzed by Jacob Straight-Line Method (Cooper and Jacob, 1946).
- Calculations rounded to 1 or 2 significant figures.
Raw data and calculations included in Appendix H.

Table 9. Vertical Permeability of Confining Layer Estimated by Modeling.

Well Number	MW-1D	MW-8D	MW-13D	PH Well
<u>MODEL INPUT VARIABLES</u>				
Distance from Pumped Well	690 ft	1,170 ft	1,275 ft	1,420 ft
Transmissivity	12,000 ft ² /day 90,000 gpd/ft	12,000 ft ² /day 90,000 gpd/ft	18,000 ft ² /day 135,000 gpd/ft	14,000 ft ² /day 105,000 gpd/ft
Storativity	0.00046 unitless	0.00051 unitless	0.00037 unitless	0.00019 unitless
Assumed Thickness of Confining Layer	20 ft	20 ft	20 ft	20 ft
Drawdown Observed	4.66 ft	4.55 ft	3.15 ft	4.53 ft
<u>MODEL OUTPUT VALUES</u>				
Drawdown (w/out leakage) Predicted by Model	6.86 ft	5.04 ft	4.27 ft	6.87 ft
Vertical Permeability (K _v) in Confining Layer to Produce Observed Drawdown	0.274 gpd/ft ² 3.66x10 ⁻² ft/day 1.29x10 ⁻⁵ cm/sec	0.055 gpd/ft ² 7.35x10 ⁻³ ft/day 2.59x10 ⁻⁶ cm/sec	0.187 gpd/ft ² 2.50x10 ⁻² ft/day 8.82x10 ⁻⁶ cm/sec	0.123 gpd/ft ² 1.64x10 ⁻² ft/day 5.80x10 ⁻⁶ cm/sec

NOTE:

Calculations based on Hantush-Jacob Equation (Model B10, Walton, 1985)

Table 10. Vertical Gradient Calculations from Site Measurements.

WELL	Screen Elevation	Screen Separation	After 8 Hours of Pumping			At End of Recovery Phase		
			Water Elevation	Level Difference	Vertical Gradient (i _v)	Water Elevation	Level Difference	Vertical Gradient (i _v)
MW-1D	696		811.73			816.39		
MW-1I	760	64	814.04	-2.31	-0.036	815.51	0.88	0.014
MW-1S	810	<u>50</u>	814.97	<u>-0.93</u>	<u>-0.019</u>	815.29	<u>0.22</u>	<u>0.004</u>
	Total:	114	Total:	-3.24	-0.028	Total:	1.10	0.010
MW-8D	693		812.05			816.60		
MW-8S	817	124	815.49	-3.44	-0.028	815.53	1.07	0.009
MW-13D	688		812.44			815.59		
MW-13S	817	129	814.63	-2.19	-0.017	814.85	0.74	0.006
PH Well	685		812.12			816.65		
MW-9S	815	130	815.53	-3.41	-0.026	815.56	1.09	0.008

NOTES:

Water levels and well elevations recorded in feet.

Positive values indicate upward gradient.

Negative values indicate downward gradient.

Table 11. Calculation of Seepage between the Upper and Lower Aquifers.

WELL NEST	Vertical Permeability Across Confining Layer (K _v) (feet/day)	After 8 Hours of Pumping		At End of Recovery Phase	
		Vertical Gradient (i _v)	Seepage Volume cubic feet per acre per day	Vertical Gradient (i _v)	Seepage Volume cubic feet per acre per day
MW-1S MW-1D	0.08	-0.028	-98	0.004	35
MW-8S MW-8D	0.03	-0.028	-37	0.009	12
MW-13S MW-13D	0.06	-0.017	-44	0.006	16
MW-9S PH Well	0.04	-0.026	-45	0.008	14
Average leakage per day per acre					
Geometric Mean (cubic feet):			-52	18	

NOTES:

Vertical permeability calculations summarized in Appendix H-3.

Negative values indicate leakage from upper aquifer to lower aquifer.

Positive values indicate leakage from lower aquifer to upper aquifer.

Calculation based on 43,560 square feet/acre.

Seepage volume precision is only valid to 1 significant figure.

TABLE 12
SUMMARY OF FIELD SAMPLING ACTIVITIES
PHASE I AND II RI

<u>Activity</u>	<u>No. Samples Collected Phase I</u>	<u>Collection Dates (1988)</u>	<u>No. Samples Collected Phase II</u>	<u>Collection Dates (1988)</u>	<u>Total</u>
<u>Soil Sampling</u>					
- Soil Borings (1)	74	2/23 to 2/29	40	7/29 to 8/01	113
- Surface Soil	6	3/19			6
<u>Groundwater Sampling</u>					
- Monitoring Wells	17	3/14 to 3/18	21	8/30 to 9/12	40
- Municipal Wells			2 (2)	9/13	2
- Private Wells			2 (2)	9/13	2
<u>Surface Water</u>	13	3/17 to 3/18			13
<u>Sediments</u>	18	3/17 to 3/19			18

- (1) Phase II soil boring samples were analyzed for the volatiles fraction only (with the exception of 2 samples).
- (2) Both municipal wells and 1 private well were resampled on 10/28/88 and reanalyze for volatiles only.

TABLE 13
LISTING OF CONSTITUENT ORGANIC GROUPINGS

Volatiles

<u>Total Chlorinated Ethenes</u>	<u>Total Chlorinated Ethanes</u>	<u>Toluene</u>
Vinyl Chloride	1,1-Dichloroethane	Toluene
Trichloroethene	Chloroethane	
trans-1,2-Dichloroethene	1,1,1-Trichloroethane	
1,1-Dichloroethene		

Semi-Volatiles

<u>PAH</u>	<u>Phenols</u>	<u>Phthalates</u>
Naphthalene	Phenol	di-n-Butylphthalate
2-methylnaphthalene	Benzoic Acid	bis(2-ethylhexyl)phthalate
Acenaphthene	2-Methylphenol	di-n-Octylphthalate
Fluorene	4-Methylphenol	Butylbenzylphthalate
Benzo(A)anthracene	2,4-Dimethylphenol	Diethylphthalate
Phenanthrene	Benzyl Alcohol	
Anthracene		
Fluoranthene		
Pyrene		
Chrysene		
Benzo(B)fluoranthene		
Benzo(K)fluoranthene		
Benzo(A)pyrene		
Indeno(1,2,3-CD)pyrene		

Pesticides/PCB's

Gamma-Chlordane
4,4'-DDD
4,4'-DDE
Endrin
Aroclor-1248
Aroclor-1254
Aroclor-1260

TABLE 14
FREQUENCY OF CHEMICAL DETECTS FOR VARIOUS MEDIA

<u>Chemical</u>	<u>Soil Borings</u>		<u>Surface Soil</u>	<u>Surface Water</u>	<u>Sediment</u>	<u>Groundwater</u>		<u># of media detected in</u>
	<u>Round I</u>	<u>Round II*</u>				<u>Round I</u>	<u>Round II*</u>	<u>Round I</u>
VOLATILES								
Vinyl Chloride	1				1	7	12	3
Methylene Chloride	12	1		1				2
Acetone	31					1		2
Carbon Disulfide	5						2	1
1,1-Dichloroethane	6	5		1	2	1	6	4
Total 1,2-Dichloroethene	16	17	1	6	5	6	10	5
Chloroform	34	2	5		3		3	3
2-Butanone	6				2	1		3
1,1,1-Trichloroethane	7	9			1		4	2
1,2-Dichloropropane	2	1					1	1
Trichloroethene	16	27	1		3	1	3	4
Benzene	2		1				2	2
Bromoform	1							1
4-Methyl-2-Pentanone	1						1	1
Tetrachloroethene	15	20			2		1	2
Toluene	51	12	1		2		7	3
Chlorobenzene	1							1
Ethylbenzene	8	2	1		3		1	3
Styrene	1							1
Total Xylenes	7	3	1		2		1	3
Chloroethane							1	
1,1-Dichloroethene							3	
SEMI-VOLATILES								
2,4-Dimethylphenol							1	
2-Methylphenol						3	3	1

TABLE 14 (continued)

<u>Chemical</u>	<u>Soil Borings</u>		<u>Surface Soil</u>	<u>Surface Water</u>	<u>Sediment</u>	<u>Groundwater</u>		<u># of media detected in Round I</u>
	<u>Round I</u>	<u>Round II*</u>				<u>Round I</u>	<u>Round II*</u>	
SEMI-VOLATILES (continued)								
Acenaphthene	1							1
Diethylphthalate	1			8		1	3	3
Fluorene	1							1
Phenanthrene	6		1					2
Anthracene	1							1
Di-n-Butylphthalate	11			1	1		2	3
Fluoranthene	4							1
Pyrene	4		1	1				3
Butylbenzylphthalate	1		1					2
Benzo(a)anthracene	1							1
Chrysene	1							1
Bis(2-ethylhexyl)phthalate	24		5	1	10	3	4	5
Di-n-octylphthalate	4							1
Benzo(b)fluoranthene	2							1
Benzo(k)fluoranthene	2							1
Benzo(a)pyrene	1							1
Indeno(1,2,3-cd)Pyrene	1							1
Benzyl Alcohol						1		1
Benzoic Acid						1		1
Isophorone							2	
PESTICIDES/PCBs								
Gamma-Chlordane			1					1
4,4' -DDE	2							1
Endrin	1							1
4,4' -DDD	1							1
Aroclor-1248	1		1					2
Aroclor-1254	1				2			2

TABLE 14 (continued)

<u>Chemical</u>	<u>Soil Borings</u>		<u>Surface Soil</u>	<u>Surface Water</u>	<u>Sediment</u>	<u>Groundwater</u>		# of media detected in <u>Round I</u>
	<u>Round I</u>	<u>Round II*</u>				<u>Round I</u>	<u>Round II*</u>	
METALS (continued)								
Aluminum	47		6	13	18	3	12	5
Antimony							2	
Arsenic	55		6	2	18	11	15	5
Barium	72		6	13	18	15	22	5
Beryllium	34		5	2	15			4
Cadmium	25		6		7	1		4
Calcium	72		6	13	18	15	22	5
Chromium, Total	69		6		18	1	1	4
Cobalt	57		6		18		1	3
Copper	70		6	10	18	2	10	5
Iron	72		6	13	18	12	22	5
Lead	72		6	3	17	1	1	5
Magnesium	72		6	13	18	15	22	5
Manganese	55		6	12	18	14	21	5
Mercury	12		1					2
Nickel	70		6	1	18		12	4
Potassium	71		6	13	18	14	22	5
Selenium	11						4	1
Silver	13		5		7		1	3
Sodium	5		3	13	1	15	22	5
Thallium	24		1		1	7		4
Vanadium	69		6		18	1	1	4
Zinc	72		6	12	18	5	21	5
Cyanide, Total	51		6	13	18	11	14	5

** Numbers in parentheses represent total number of samples analyzed for each medium.

* Round II Soil borings were analyzed for volatiles only. Round II Groundwater samples were analyzed for the full volatile, semi-volatile, pesticide/PCB, and metal fractions.

TABLE 15
SUMMARY OF CHEMICAL CONCENTRATIONS
FOR PHASE I SOIL BORING SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 74)</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Volatiles</u>				
Vinyl Chloride	1	8	8	8
Methylene Chloride	12	7	310	25
Acetone	31	13	13,000	89
Carbon Disulfide	5	3	14	6
1,1-Dichloroethane	6	6	490	36
Total 1,2-Dichloroethene	16	2	71,000	169
Chloroform	34	2	36	6
2-Butanone	6	5	81	19
1,1,1-Trichloroethane	7	4	1,100	74
1,2-Dichloropropane	2	70	1,600	335
Trichloroethene	16	5	43,000	73
Benzene	2	2	4	3
Bromoform	1	4,700	4,700	4,700
4-Methyl-2-pentanone	1	27	27	27
Tetrachloroethene	15	4	5,400	29
Toluene	51	22	59,000	171
Chlorobenzene	1	24	24	24
Ethylbenzene	8	2	1,200	71
Styrene	1	3	3	3
Total Xylenes	7	14	4,300	389
<u>Semi-Volatiles</u>				
Phenol	1	240	240	240
4-Methylphenol	1	210	210	210
Naphthalene	3	78	2,100	253
2-Methylnaphthalene	3	83	1,300	359
Acenaphthene	1	1,100	1,100	1,100
Diethylphthalate	1	23	23	23
Fluorene	1	1,300	1,300	1,300
Phenanthrene	6	41	18,000	434
Anthracene	1	4,100	4,100	4,100
Di-n-butylphthalate	11	56	29,000	201
Fluoranthene	4	46	28,000	391
Pyrene	4	44	24,000	389
Butylbenzylphthalate	1	21,000	21,000	21,000
Benz(a)anthracene	1	13,000	13,000	13,000
Chrysene	1	13,000	13,000	13,000
bis(2-ethylhexyl)phthalate	24	76	140,000	371
Di-n-octylphthalate	4	85	950	258
Benzo(b)fluoranthene	2	65	11,000	846
Benzo(k)fluoranthene	2	65	11,000	846
Benzo(a)pyrene	1	12,000	12,000	12,000
Indeno(1,2,3-cd)pyrene	1	8,100	8,100	8,100
Benzo(g,h,i)perylene	1	6,800	6,800	6,800

TABLE 15
(continued)

<u>Chemical*</u>	<u>Frequency of Detection (Total = 74)</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Pesticides/PCBs</u>				
4,4-DDE	2	27	100	52
Endrin	1	19	19	19
4,4-DDD	1	57	57	57
Aroclor-1248	1	230	230	230
Aroclor-1254	1	640	640	640
Aroclor-1260	1	1,400	1,400	1,400
<u>Metals</u>				
	<u>Frequency of Detection Total = 74</u>	<u>Minimum Concentration (mg/kg)</u>	<u>Maximum Concentration (mg/kg)</u>	<u>Geometric Mean (mg/kg)</u>
Aluminum	47	1,570	14,900	4,325
Arsenic	55	1.5	25.2	9
Barium	72	8.2	409	38
Beryllium	34	0.23	0.91	0.42
Cadmium	25	1.2	109	2
Calcium	72	1,180	195,000	21,987
Chromium, total	69	3.7	254	12
Cobalt	57	1.9	17	6
Copper	70	3.9	841	19
Iron	72	4,350	171,000	13,730
Lead	72	2.4	1,980	11
Magnesium	72	908	42,700	8,297
Manganese	55	34.3	1,050	320
Mercury	12	0.028	0.23	0.06
Nickel	70	4.6	300	15
Potassium	71	197	12,300	734
Selenium	11	1.5	4.5	2
Silver	13	0.2	4.6	2
Sodium	5	429	3,120	946
Thallium	24	0.2	1	0.4
Vanadium	69	5	35.3	13
Zinc	72	17.6	1,870	56
Cyanide, total	51	2.7	111	12

*Does not include non-detects or data which did not meet validation criteria.

TABLE 16
SUMMARY OF CHEMICAL CONCENTRATIONS
FOR PHASE II SOIL BORING SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 38)</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Volatiles</u>				
Methylene Chloride	1	20	20	20
1,1-Dichloroethane	5	2	150	10
Total 1,2-Dichloroethene	17	1	82,000	83
Chloroform	2	2	2	2
1,1,1-Trichloroethane	9	2	9,600	28
1,2-Dichloropropane	1	4	4	4
Trichloroethene	27	1	83,000	20
1,1,2-Trichloroethane	1	2	2	2
Tetrachloroethene	20	1	1,400	22
Toluene	12	1	580	5
Ethylbenzene	2	8	600	69
Total Xylenes	3	25	2,800	412
 <u>Semi-Volatiles</u> <u>(Total = 2)</u>				
Naphthalene	1	3,800	3,800	3,800
2-Methylnaphthalene	1	24,000	24,000	24,000
Acenaphthene	1	1,600	1,600	1,600
Dibenzofuran	1	2,200	2,200	2,200
Fluorene	1	1,900	1,900	1,900
Phenanthrene	1	5,500	5,500	5,500
Anthracene	1	890	890	890
Fluoranthene	1	3,000	3,000	3,000
Pyrene	1	1,900	1,900	1,900
Benz(a)anthracene	1	1,300	1,300	1,300
Chrysene	1	1,400	1,400	1,400
Benzo(b)fluoranthene	1	2,900	2,900	2,900
Benzo(k)fluoranthene	1	2,900	2,900	2,900
Benzo(a)pyrene	1	1,300	1,300	1,300
Indeno(1,2,3-cd)pyrene	1	490	490	490
Benzo(g,h,i)perylene	1	560	560	560

TABLE 16
(continued)

<u>Chemical*</u>	<u>Frequency of Detection (Total = 2)</u>	<u>Minimum Concentration (mg/kg)</u>	<u>Maximum Concentration (mg/kg)</u>	<u>Geometric Mean (mg/kg)</u>
<u>Metals</u>				
Aluminum	2	13,600	22,600	17,977
Antimony	2	13.2	34.2	25
Arsenic	2	19.5	36.4	35
Barium	2	149	516	285
Cadmium	2	4.7	15.8	10
Calcium	2	34,600	46,600	40,154
Chromium, total	2	49.5	57.9	56
Cobalt	2	13	20	18
Copper	2	218	6,890	3,050
Iron	2	110,000	155,000	143,579
Lead	2	622	1,650	1,335
Magnesium	2	4,870	7,790	6,159
Manganese	2	714	1,460	1,144
Mercury	2	0.1	0.4	0.2
Nickel	2	40.5	65	59
Potassium	2	1,120	1,610	1,349
Silver	2	2.3	4.8	3
Vanadium	2	17.3	20.2	19
Zinc	2	878	3,000	1,749

* Does not include non-detects or data which did not meet validation criteria.

**Based on Lindsay, 1979, Table 1.1.

TABLE 17
MEAN CONCENTRATION OF ELEMENTS IN SUBSURFACE SOILS
COMPARED TO NATURAL SOILS***
(Lindsay, 1979)

<u>Element</u>	<u>Round 1 Soil Boring Geometric Mean (mg/kg)</u>	<u>Average in Natural Soils* (mg/kg)</u>
Aluminum	4,325	71,000
Arsenic**	9	5
Barium	38	430
Beryllium	0.42	6
Cadmium**	2	0.06
Calcium**	21,987	13,700
Chromium, total	12	100
Cobalt	6	8
Copper	19	30
Iron	13,730	38,000
Lead**	11	10
Magnesium**	8,297	5,000
Manganese	320	600
Mercury**	0.06	0.03
Nickel	15	40
Potassium	734	8,300
Selenium**	2	0.3
Silver**	2	0.05
Sodium	946	6,300
Thallium	0.4	--
Vanadium	13	100
Zinc**	56	50

* From Lindsay.

** Indicates geometric mean for this element exceeded expected mean for natural soils.

*** Background data available for metals only.

TABLE 18
MAXIMUM DETECTED CONCENTRATIONS OF ELEMENTS
IN SUBSURFACE SOILS COMPARED TO THE COMMON RANGE FOR NATURAL SOILS****

<u>Element</u>	<u>Round 1 Soil Boring Maximum Concentration (mg/kg)</u>	<u>Common Range for Natural Soils* (mg/kg)</u>	<u>Ohio Farm Soils*** (mg/kg)</u>
Aluminum	14,900	10,000 - 300,000	
Arsenic	25.2	1 - 50	
Barium	409	100 - 3,000	
Beryllium	0.91	0.1 - 40	
Cadmium**	109	0.01 - 0.70	0 - 2.9
Calcium	195,000	7,000 - 500,000	
Chromium, total	254	1 - 1,000	4 - 23
Cobalt	17	1 - 40	
Copper**	841	2 - 100	11 - 37
Iron	171,000	7,000 - 550,000	
Lead**	1,980	2 - 200	9 - 39
Magnesium**	42,700	600 - 6,000	
Manganese	1,050	20 - 3,000	
Mercury	0.23	0.01 - 0.3	
Nickel	300	5 - 500	9 - 38
Potassium	12,300	400 - 30,000	
Selenium	4.5	5 - 50	
Silver	4.6	0.01 - 5	
Sodium	3,120	750 - 7,500	
Thallium	1	---	
Vanadium	35.3	20 - 500	
Zinc**	1,870	10 - 300	47 - 138

* From Lindsay, 1979.

** Indicates maximum concentration detected at site exceeds expected range for natural soils.

*** Logan and Miller, 1983.

**** Background data available for metals only.

TABLE 19
SUMMARY OF CHEMICAL CONCENTRATIONS
FOR ON-SITE SURFACE SOILS

<u>Chemical*</u>	<u>Frequency of Detection (Total = 6)</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Volatiles</u>				
Total 1,2-Dichloroethene	1	19	19	19
Chloroform	5	6	22	9
Trichloroethene	1	6	6	6
Benzene	1	3	3	3
Toluene	1	72	72	72
Ethylbenzene	1	45	45	45
Total Xylenes	1	310	310	310
<u>Semi-Volatiles</u>				
2-Methylphthalene	1	21,000	21,000	21,000
Phenanthrene	1	23,000	23,000	23,000
Pyrene	1	1,400	1,400	1,400
Butylbenzylphthalate	1	140	140	140
bis(2-ethylhexyl)phthalate	5	77	16,000	721
<u>Pesticides/PCBs</u>				
Gamma-Chlordane	1	420	420	420
Aroclor 1248	4	150	3,400	1,407
<u>Metals</u>				
		<u>(mg/kg)</u>	<u>(mg/kg)</u>	<u>(mg/kg)</u>
Aluminum	6	1,900	12,900	7,996
Arsenic	6	4.9	19.3	12
Barium	6	20	291	132
Beryllium	5	0.22	0.91	1
Cadmium	6	1.3	695	17
Calcium	6	2,030	146,000	10,724
Chromium, total	6	12.5	4,290	67
Cobalt	6	1.3	14.3	8
Copper	6	3.5	221	28
Iron	6	4,920	104,000	26,807
Lead	6	13.8	265	34
Magnesium	6	2,360	90,800	5,583
Manganese	6	131	2,140	1,029
Mercury	1	0.1	0.1	0.1
Nickel	6	7.1	525	57
Potassium	6	568	1,090	837
Silver	5	1.9	13.8	3
Sodium	3	777	4,400	1,705
Thallium	1	0.49	0.49	0.49
Vanadium	6	6.7	122	29
Zinc	6	95.3	62,800	626
Cyanide, total	6	30.4	1,920	112

** Does not include non-detects or data which did not meet validation criteria.

TABLE 19 (continued)

Round 1 Soil Borings - 0 to 2 Feet in Depth

<u>Chemical</u>	<u>Frequency of Detection</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Volatiles</u>				
Total 1,2-Dichloroethene	3	14	20	16
Chloroform	13	3	36	7
Trichloroethene	4	12	390	47
Toluene	17	22	520	120
Methylene Chloride	2	64	80	14
Acetone	9	14	14	14
2-Butanone	1	18	18	18
4-Methyl-2-Pentanone	1	27	27	27
Tetrachloroethene	7	9	67	21
Ethylbenzene	1	9	9	9
Total Xylenes	1	56	56	56
<u>Semi-Volatiles</u>				
Phenanthrene	5	41	18,000	339
Fluoranthene	3	44	24,000	575
bis(2-ethylhexyl)phthalate	8	97	2,900	310
Phenol	1	240	240	240
4-Methylphenol	1	210	210	210
Naphthalene	2	78	99	88
2-Methylnaphthalene	2	83	430	189
Acenaphthalene	1	1,100	1,100	1,100
Diethylphthalate	1	23	23	23
Fluorene	1	1,300	1,300	1,300
Anthracene	1	4,100	4,100	4,100
Di-n-butylphthalate	4	68	200	93
Pyrene	3	44	24,000	575
Benzo(a)anthracene	1	13,000	13,000	13,000
Chrysene	1	13,000	13,000	13,000
Benzo(b)fluoranthene	1	11,000	11,000	11,000
Benzo(k)fluoranthene	1	11,000	11,000	11,000
Benzo(a)pyrene	1	12,000	12,000	12,000
Indeno(1,2,3-cd)pyrene	1	8,100	8,100	8,100
Benzo(g,h,i)perylene	1	6,800	6,800	6,800
<u>Pesticides/PCBs</u>				
4,4'-DDE	1	100	100	100
Endrin	1	19	19	19
Aroclor 1254	1	640	640	640
Aroclor 1260	1	1400	1400	1400

TABLE 19 (continued)

Round 1 Soil Borings - 0 to 2 Feet in Depth

<u>Chemical</u>	<u>Frequency of Detection</u>	<u>Minimum Concentration (mg/kg)</u>	<u>Maximum Concentration (mg/kg)</u>	<u>Geometric Mean (mg/kg)</u>
<u>Metals</u>				
Aluminum	17	2,770	13,500	5,803
Arsenic	19	2.7	19.5	8
Barium	26	9.6	409	59
Beryllium	15	0.29	0.91	0.48
Cadmium	8	1.2	5.4	2
Calcium	26	1,360	126,000	6,865
Chromium, total	25	6.2	254	15
Cobalt	20	3.4	17.0	6
Copper	25	9.6	328	21
Iron	26	7,120	51,800	13,840
Lead	26	4.5	143	18
Magnesium	26	908	21,000	4,471
Manganese	20	138	845	334
Mercury	6	0.03	0.23	0.06
Nickel	26	7.1	29.8	14
Potassium	25	229	12,300	718
Selenium	5	1.5	2.0	2
Silver	6	0.2	4.6	2
Sodium	2	714	3,120	56
Thallium	9	0.2	0.6	0.4
Vanadium	26	7.3	35.3	15
Zinc	26	35	378	69
Cyanide, total	21	3.9	111	26.3

TABLE 20
MEAN CONCENTRATIONS OF ELEMENTS
IN ON-SITE SURFACE SOILS COMPARED TO NATURAL SOILS***

<u>Element</u>	<u>Round 1 Surface Soil Geometric Mean (mg/kg)</u>	<u>Average in Natural Soils* (mg/kg)</u>
Aluminum	7,996	71,000
Arsenic	12	5
Barium	132	430
Beryllium	1	6
Cadmium**	17	0.06
Calcium	10,724	13,700
Chromium, total	67	100
Cobalt	8	8
Copper	28	30
Iron	26,807	38,000
Lead**	34	10
Magnesium**	5,583	5,000
Manganese**	1,029	600
Mercury**	0.1	0.03
Nickel**	57	40
Potassium	837	8,300
Silver**	3	0.05
Sodium	1,705	6,300
Thallium	0.49	--
Vanadium	29	100
Zinc**	626	50

* From Lindsay, 1979.

** Indicates geometric mean for this element exceeded expected mean for natural soils.

*** Background data available for metals only.

TABLE 21
MAXIMUM DETECTED CONCENTRATION OF ELEMENTS IN SURFACE SOILS
COMPARED TO THE COMMON RANGE FOR NATURAL SOILS***

<u>Element</u>	<u>Round 1 Surface Soil Maximum Concentration (mg/kg)</u>	<u>Common Range for Natural Soils* (mg/kg)</u>
Aluminum	12,900	10,000 - 300,000
Arsenic	19.3	1 - 50
Barium	291	100 - 3,000
Beryllium	0.91	0.1 - 40
Cadmium**	695	0.01 - 0.70
Calcium	146,000	7,000 - 500,000
Chromium, total**	4,290	1 - 1,000
Cobalt	14.3	1 - 40
Copper**	221	2 - 100
Iron	104,000	7,000 - 550,000
Lead**	265	2 - 200
Magnesium**	90,800	600 - 6,000
Manganese	2,140	20 - 3,000
Mercury	0.1	0.01 - 0.3
Nickel**	525	5 - 500
Potassium	1,090	400 - 30,000
Silver**	13.8	0.01 - 5
Sodium	4,400	750 - 7,500
Thallium	0.49	---
Vanadium	122	20 - 500
Zinc**	62,800	10 - 300

* From Lindsay, 1979.

** Indicates maximum concentration detected at site exceeds expected range for natural soils.

*** Background data available for metals only.

TABLE 22
SUMMARY OF CHEMICAL CONCENTRATIONS FOR
ROUND I GROUNDWATER MONITORING WELL SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 17)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Volatiles</u>				
Vinyl Chloride	7	4	5,500	56
Acetone	1	270	270	270
1,1-Dichloroethane	1	630	630	630
Total 1,2-Dichloroethene	5	44	56,000	5,551
2-Butanone	1	23	23	23
Trichloroethene	1	18,000	18,000	18,000
<u>Semi-Volatiles</u>				
Benzyl Alcohol	1	14	14	14
2-Methylphenol	3	2	13	4
4-Methylphenol	2	2	5	3
Benzoic Acid	1	5	5	5
Naphthalene	1	0.08	0.08	0.08
Diethylphthalate	1	0.08	0.08	0.08
bis(2-ethylhexyl)phthalate	3	4	29	15
<u>Metals</u>				
Aluminum	3	48.2	30,200	1,082
Arsenic	11	3	57.1	7
Barium	15	9.3	1,870	137
Cadmium	1	5	5	5
Calcium	15	57,400	276,000	169,105
Chromium, total	1	17	17	17
Copper	2	31	34	32
Iron	12	74.2	10,400	2,054
Lead	1	12	12	12
Magnesium	15	111	74,600	31,148
Manganese	14	58	1,440	422
Potassium	14	2,100	35,900	9,602
Sodium	15	11,200	134,000	36,375
Thallium	7	1	2	1
Vanadium	1	6.5	6.5	7
Zinc	5	4.1	79	16
Cyanide, total	11	6.0	264	35

* Does not include non-detects or data which did not meet validation criteria.

TABLE 23
SUMMARY OF CHEMICAL CONCENTRATIONS
FOR ROUND II GROUNDWATER MONITORING WELL SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 21)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Volatiles</u>				
Vinyl Chloride	12	1.3	2,800	36
Chloroethane	1	1	1	1
Carbon Disulfide	2	0.59	2.3	1
1,1-Dichloroethene	3	16	92	31
1,1-Dichloroethane	6	2	270	36
Total 1,2-Dichloroethene	10	4	38,000	460
Chloroform	3	0.7	12	3
1,1,1-Trichloroethane	4	0.17	11	2
1,2-Dichloropropane	1	8.4	8.4	8
Trichloroethene	3	1.1	25,000	38
Benzene	2	1.1	7	3
4-Methyl-2-pentanone	1	2.2	2.2	2
Tetrachloroethene	1	27	27	27
Toluene	7	0.3	3,500	4
Ethylbenzene	1	4	4	4
Total Xylenes	1	28	28	28
<u>Semi-volatiles</u>				
Phenol	1	6	6	6
2-Methylphenol	3	3	29	6
4-Methylphenol	2	3	14	6
Isophorone	2	0.8	2	1
2,4-Dimethylphenol	1	0.6	0.6	0.6
Naphthalene	1	0.1	0.1	0.1
Diethylphthalate	3	0.1	2	1
Di-n-butylphthalate	2	0.3	0.3	0.3
bis(2-ethylhexyl)phthalate	4	6	160	21

TABLE 23
(continued)

<u>Chemical*</u>	<u>Frequency of Detection (Total = 21)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Metals</u>				
Aluminum	12	30.8	23,800	149
Antimony	2	1.2	32.7	6
Arsenic	15	3	23.4	7
Barium	22	12.3	1,410	138
Calcium	22	48,100	222,000	129,470
Chromium, total	1	6.9	6.9	7
Cobalt	1	5.1	5.1	5
Copper	10	5.2	21.6	8
Iron	22	21	7,870	674
Lead	1	2.3	2.3	2
Magnesium	22	77.9	57,600	27,354
Manganese	21	29.1	1,370	254
Nickel	12	9	43.8	14
Potassium	22	1,860	37,300	7,096
Selenium	4	1.8	2.2	2
Silver	1	4.1	4.1	4
Sodium	22	11,200	111,000	29,063
Vanadium	1	5.3	5.3	5
Zinc	21	3.5	65.7	18
Cyanide, total	14	8.0	150	25

* Does not include non-detects nor data which did not meet validation criteria.

TABLE 24
SUMMARY OF CHEMICAL CONCENTRATIONS FOR
MUNICIPAL WATER SUPPLY WELL SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 2)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Semi-Volatiles</u>				
Phenol	1	2	2	2
Diethylphthalate	2	0.2	0.3	0.25
Di-n-octylphthalate	1	3	3	3
<u>Metals</u>				
Aluminum	1	43.9	43.9	44
Arsenic	2	5.6	8.6	7
Barium	2	126	150	137
Calcium	2	77,700	88,100	82,700
Copper	1	5.0	5.0	5
Iron	2	1,130	1,540	1,320
Magnesium	2	35,900	38,300	37,100
Manganese	2	132	137	134
Potassium	2	1,630	1,660	1,640
Sodium	2	121,000	153,000	136,000
Zinc	2	6.9	7.3	7

* Does not include non-detects or data which did not meet validation criteria.

TABLE 25
SUMMARY OF CHEMICAL CONCENTRATIONS FOR
PRIVATE WATER SUPPLY WELL SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 3)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Semi-Volatiles</u>				
Diethylphthalate	1	2.0	2.0	2
Butylbenzylphthalate	1	0.2	0.2	0.2
<u>Metals</u>				
Aluminum	2	47.9	53.3	51
Barium	3	111	255	183
Calcium	3	96,000	136,000	110,000
Iron	3	1,370	4,500	2,340
Magnesium	3	46,500	49,600	47,600
Manganese	3	147	151	145
Potassium	3	1,660	2,270	1,920
Sodium	3	164,000	194,000	175,000
Zinc	3	4.6	154	18

* Does not include non-detects or data which did not meet validation criteria.

TABLE 26
 CLASSIFICATION OF DISSOLVED INORGANIC
 CONSTITUENTS IN NATURALLY OCCURRING GROUNDWATER
 (from Davis and DeWiest, 1966)

Major constituents (greater than 5 mg/L)

Bicarbonate alkalinity	Magnesium
Calcium	Sodium
Chloride	Sulfate

Minor constituents (0.01-10.0 mg/L)

Fluoride	Nitrate
Iron	Potassium

Trace constituents (less than 0.1 mg/L)

Aluminum	Manganese
Antimony	Nickel
Arsenic	Phosphate
Barium	Selenium
Beryllium	Silver
Cadmium	Thallium
Chromium	Vanadium
Cobalt	Zinc
Copper	

TABLE 27
SUMMARY OF CHEMICAL CONCENTRATIONS FOR
SURFACE WATER SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 13)</u>	<u>Minimum Concentration (ug/L)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Geometric Mean (ug/L)</u>
<u>Volatiles</u>				
Methylene Chloride	1	6	6	6
1,1-Dichloroethane	1	66	66	66
Total 1,2-Dichloroethene	6	1	1,600	8
<u>Semi-Volatiles</u>				
Diethylphthalate	8	0.08	0.6	0.1
Di-n-butylphthalate	1	0.2	0.2	0.2
Pyrene	1	0.1	0.1	0.1
Bis(2-ethylhexyl)phthalate	1	0.6	0.6	0.6
<u>Metals</u>				
Aluminum	13	51.9	331	178
Arsenic	2	3.4	8	5
Barium	13	46.4	105	66
Beryllium	2	1.1	1.1	1
Calcium	13	39,900	129,000	82,835
Copper	10	6	18.1	9
Iron	13	97.4	4,070	604
Lead	3	2.5	3.7	3
Magnesium	13	14,500	32,000	23,274
Manganese	12	19.4	2,070	119
Nickel	1	8	8	8
Potassium	13	2,190	43,100	5,460
Sodium	13	4,130	277,000	16,941
Zinc	12	3	12.1	7
Cyanide, total	13	20	315	50

* Does not include non-detects or data which did not meet validation criteria.

TABLE 28
MAXIMUM AND MEAN CONCENTRATIONS FOR ELEMENTS
DETECTED IN SURFACE WATER SAMPLES
COMPARED TO EPA AMBIENT WATER QUALITY CRITERIA

Maximum and mean concentrations for elements detected in surface water samples compared to EPA Ambient Water Quality Criteria.

<u>Element(1)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Mean Concentration (ug/L)</u>	<u>AWQC Human (ug/L)</u>	<u>AWQC Aquatic Life (ug/L)</u>
Arsenic	8.0	5	.0022(2)	190(3)
Beryllium	1.1	1	.0037(2)	5.3(4)
Copper*	18.1	9	--	6.5(3)
Lead**	3.7	3	50(5)	1.3(3)
Nickel	8.0	8	13.4(5)	56(3)
Zinc	12.1	7	--	47(3)
Cyanide, total	315	50	200(5)	5.2(3)

(1) Does not include non-detects or elements for which Ambient Water Quality Criteria do not exist.

(2) Ambient Water Quality Criteria (AWQC) for carcinogenicity protection (incremental increased lifetime cancer risk of 10^{-6}) in humans ingesting water and organisms.

(3) Ambient Water Quality Criteria (AWQC) for the protection of aquatic life, freshwater chronic exposure.

(4) Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (lowest reported toxic concentration, chronic).

(5) Ambient Water Quality Criteria (AWQC) for toxicity protection of human health, ingesting water and organisms.

Note: Arsenic and lead are the only elements detected in surface water samples for which EPA Maximum Containment Levels for Drinking Water exist. (Arsenic MCL = 50 ug/L; lead = 50 ug/L).

* 8 surface water locations exceeded AWQC (copper) for Aquatic Life: SW-1, SW-2, SW-5, SW-6, SW-7, SW-10, SW-11 and SW-13.

**3 surface water locations exceeded AWQC (lead) for Aquatic Life: SW-9, SW-12 and SW-13.

TABLE 29
SUMMARY OF CHEMICAL CONCENTRATIONS
FOR SEDIMENT SAMPLES

<u>Chemical*</u>	<u>Frequency of Detection (Total = 18)</u>	<u>Minimum Concentration (ug/kg)</u>	<u>Maximum Concentration (ug/kg)</u>	<u>Geometric Mean (ug/kg)</u>
<u>Volatiles</u>				
Vinyl Chloride	1	270	270	270
1,1-Dichloroethane	2	33	1,300	207
Total 1,2-Dichloroethene	5	3	1,100	54
Chloroform	3	3	16	6
2-Butanone	2	8	39	18
1,1,1-Trichloroethane	1	3	3	3
Trichloroethene	3	4	44	17
Tetrachloroethene	2	5	7	6
Toluene	2	150	210	177
Ethylbenzene	3	3	33	7
Total Xylenes	2	5	48	15
<u>Semi-Volatiles</u>				
4-Methylphenol	1	86	86	86
Di-n-butylphthalate	1	27	27	27
bis(2-ethylhexyl)phthalate	10	50	220	91
<u>Pesticides-PCBs</u>				
Aroclor 1254	2	160	290	241
Aroclor 1260	1	200	200	200
<u>Metals</u>				
		<u>(mg/kg)</u>	<u>(mg/kg)</u>	<u>(mg/kg)</u>
Aluminum	18	2,210	9,920	4,876
Arsenic	17	2.3	19.7	8
Barium	18	21.3	80.1	43
Beryllium	15	0.29	0.85	0.48
Cadmium	7	1.3	2.6	2
Calcium	18	32,600	104,000	57,385
Chromium, total	18	6.7	39.5	11
Cobalt	18	2.1	7.1	5
Copper	18	11.8	247	27
Iron	18	5,950	22,500	12,865
Lead	17	3.3	374	13
Magnesium	18	6,400	30,400	13,516
Manganese	18	209	629	354
Nickel	18	7.2	24.4	15
Potassium	18	390	1,410	820
Silver	7	1.1	1.8	1
Sodium	1	1,110	1,110	1,110
Thallium	1	0.95	0.95	1
Vanadium	18	8	27	15
Zinc	18	21	397	62
Cyanide, total	18	4.36	66.4	22

* Does not include non-detects or data which did not meet validation criteria.

TABLE 30

NO TABLE

TABLE 31

NO TABLE

TABLE 32
DATA QUALIFIER DEFINITIONS FOR ORGANIC COMPOUNDS

U	The material was analyzed for, but was not detected. Refer to contract required quantitation limit.
R	The data are unusable (compound may or may not be present). Resampling and reanalysis is necessary for verification.
J	The associated numerical value is an estimated quantity. Refer to Table 3 for conditions which require value estimation.
B	Compound was also detected in the associated method blank.
UJ	Qualifier assigned by data reviewers to indicate that although the compound was detected in the sample, it is considered to be the result of laboratory contamination (UJ) and not a component of the environmental sample. The associated value is the quantity detected in the sample and thus the estimated sample quantitation limit.
D	Sample was diluted prior to analysis.
E	The concentration of the compound exceeded the calibration range of the instrument.
A	The tentatively identified compound is a suspected aldol-condensation product.
N	Presumptive evidence of the presence of the material.

TABLE 33
EXAMPLES OF CONDITIONS WHICH REQUIRE
ESTIMATION OF ORGANICS ANALYSIS DATA

1. If the contract-required time period from the time of sampling to the time of sample extraction or analysis (holding time) is exceeded.
2. If the instrument initial or continuing calibration criteria are not within U.S. EPA established limits.
3. If the recoveries of the sample surrogate standards do not meet U.S. EPA established criteria.
4. If the response of the sample internal standards do not meet U.S. EPA established criteria.
5. If the concentration of the compound exceeds the calibration range of the instrument.
6. If the concentration of the compound is below the contract-required quantitation limit.
7. If the compound is a Tentatively Identified Compound.

TABLE 34
REFERENCE DOSES AND POTENCY FACTORS FOR THE INDICATOR CHEMICALS

Chemical	Oral*		Inhalation		Oral*	Inhalation
	<u>RFDs</u>	<u>RFD</u>	<u>RFDs</u>	<u>RFD</u>	Potency Factor	Potency Factor
	(mg/kg/d)		(mg/kg/d)		(mg/kg/d) ⁻¹	(mg/kg/d) ⁻¹
Vinyl Chloride	1.0E-03(1)		1.0E-03(1)		2.3E+00	2.95E-01
1,2-Dichloroethylene	7.9E-02(1)	7.9E-03(1)	7.9E-02(1)	7.9E-03(1)	NA	NA
Trichloroethylene	2.7E-02(1)		2.7E-02(1)		1.1E-02	<u>1.3E-02</u>
Toluene	4.0E-01	3.0E-01	1.0E+00	1.0E+00	NA	NA
bis(2-ethylhexyl) phthalate	2.0E-02(1)	2.0E-02			<u>1.4E-02</u>	
Polynuclear Aromatic Hydrocarbons	ID				1.15E+01(2)	6.1E+00(2)
Polychlorinated Biphenyls	3.0E-04(1)				7.7E+00	
Cadmium	5.0E-04(1)	5.0E-04				6.1E+00
Nickel	2.0E-02	2.0E-02				1.7E+00
Chromium (VI)	2.0E-02	5.0E-03		5.1E-03		4.1E+01
Arsenic	1.0E-03(1)	1.0E-03			1.8E+00	<u>5.0E+01</u>
Zinc	2.0E-01	2.0E-01			NA	NA
Cyanide, total	2.0E-02(1)	2.0E-02			NA	NA

(1) Derived for this assessment. See details in RI Report.

(2) Based on benzo(a)pyrene.

NA - Not Applicable.

ID - Insufficient data to derive value.

* Applied to dermal routes in addition to oral routes as a basis of conservatism.

TABLE 35
POTENTIAL EXPOSURE PATHWAYS - CURRENT SITE CONDITIONS

<u>Environmental Medium</u>	<u>Exposure Point</u>	<u>Exposed Receptors</u>	<u>Routes of Exposure</u>	<u>Pathway Complete?</u>	<u>Exposure Potential</u>	<u>Addressed in Endangerment Assessment</u>
Groundwater	Columbia City distribution system water, private well water	Residents of Columbia City, residents with private wells	Ingestion, inhalation, dermal absorption	No; municipal and private wells clean	None	No
Surface soils	On-site direct contact	Trespassers	Dermal absorption; incidental ingestion	Not determined	Low; frequency of trespass assumed to be low	Yes
		Terrestrial wildlife	Ingestion, dermal absorption	Not determined but likely	Low; site area likely supports small populations of wildlife	No
	Fugitive dusts	Trespassers, off-site residents	Inhalation, incidental	Yes	Low; amount of dusts generated expected to be low	No
	On-site direct contact	Trespassers, children playing by river	Dermal absorption, incidental ingestion	Not determined	Low; concentrations of chemicals detected in surface water are low; banks of the Blue River adjacent to the site are too steep to allow access	No
Surface water and sediments Pond on-site, Blue River		Aquatic organisms, terrestrial wildlife	Direct ingestion, bioconcentration, bioaccumulation	Not determined but likely	Low; site likely supports small animal populations	No
	Fish from Blue River	Populations consuming fish caught locally	Ingestion	Not determined	Low; Blue River does not support fishing	No

TABLE 35
(continued)

<u>Environmental Medium</u>	<u>Exposure Point</u>	<u>Exposed Receptors</u>	<u>Routes of Exposure</u>	<u>Pathway Complete?</u>	<u>Exposure Potential</u>	<u>Addressed in Endangerment Assessment</u>
Subsurface soils	On-site excavated soils	Remediation workers	Dermal absorp- tion; incidental ingestion	Yes	Low; workers wear protective clothing	No
Air	On-site, volatil- ization from soils	Trespassers	Inhalation	No; HNu air analysis negative	None	No

TABLE 36
ASSUMPTIONS AND POTENTIAL EXPOSURE PATHWAYS - FUTURE SITE CONDITIONS

<u>Assumption Future Site Conditions</u>	<u>Environmental Medium</u>	<u>Exposure Point</u>	<u>Exposed Receptors</u>	<u>Routes of Exposure</u>	<u>Exposure Potential</u>	<u>Addressed in Endangerment Assessment</u>
Contaminated groundwater plume migrates to municipal well	Groundwater	Municipal distribution system water	Columbia City residents	Ingestion, inhalation, dermal absorption	Low; well use and hydrogeology does not support migration to municipal well	Yes
Contaminated groundwater plume migrates to private well	Groundwater	Private well water	Residents with private wells	Ingestion, inhalation, dermal absorption	Low; zoning prevents well installation near the site in the future; low potential exists for contaminants to migrate to existing wells	Yes
<u>Site is developed industrial or residential</u>	Soils	On-site excavated soil	Construction workers	Dermal contact, incidental ingestion	Moderate; exposure would be limited to construction period	Yes
	Soils	On-site surface soil	Industry employees, <u>residents</u>	Dermal contact, incidental ingestion	Low; contaminated soils would likely be confined to subsurface <u>since filling would be necessary</u>	No
	Groundwater	On-site private well	Industry employees, <u>residents</u>	Ingestion, inhalation, dermal absorption	Low; domestic water use would be supplied by municipal water	No

TABLE 36
(continued)

<u>Assumption Future Site Conditions</u>	<u>Environmental Medium</u>	<u>Exposure Point</u>	<u>Exposed Receptors</u>	<u>Routes of Exposure</u>	<u>Exposure Potential</u>	<u>Addressed in Endangerment Assessment</u>
Potential flooding of Blue River resulting in contaminated surface runoff	Runoff to surface water and sediment	Blue River water	People who swim in river	Dermal absorp- tion, inciden- tal ingestion	Low; Blue River not utilized for significant recreational activity	No
			Aquatic organisms	Bioconcentra- tion	Moderate; unable to quantify	No
		Aquatic organisms	Humans/terres- trial organisms consuming aqua- tic organisms	Ingestion, bioaccumula- tion	Low/moderate; Blue River does <u>not</u> support fishing. Unable to quantify	No

TABLE 37

CURRENT AND FUTURE POTENTIAL EXPOSURE
PATHWAYS OF GREATEST CONCERN

<u>Contaminated Medium</u>	<u>Receptors</u>	<u>Contaminant Intake Route</u>
Groundwater	Municipal water users Private well water users	1. Ingestion from drinking and cooking 2. Dermal absorption while bathing 3. Inhalation of volatile compounds while showering and bathing
Soils	On-site trespassers, On-site construction workers	1. Dermal absorption 2. Incidental ingestion

TABLE 38
MAXIMUM AND AVERAGE EXPOSURE POINT CONCENTRATIONS
OF CONTAMINANTS FOR RECEPTOR DOSE CALCULATIONS

Assumptions of Site Conditions	Current		Future		Future		Future	
Exposure Pathway	Exposure of Trespassers to Contaminated Soils On-Site		Exposure of Residents to Contaminated Groundwater From Municipal Wells		Exposure of Construction Workers to Contaminated Soils On-Site		Exposure of Residents to Contaminated Groundwater from Private Wells	
Medium	Surface Soil ^a		Groundwater ^b		Subsurface Soil ^c		Groundwater ^b	
Date representation	Maximum (ug/kg)	Average (ug/kg)	Maximum (ug/L)	Average (ug/L)	Maximum (ug/kg)	Average (ug/kg)	Maximum (ug/L)	Average (ug/L)
<u>Indicator Chemical</u>								
Vinyl Chloride	ND	ND	28	0.3	8	8	187	2.0
1,2-Dichloroethane (total)	20	16	280	28	82,000	170	1,870	187
Trichloroethene	390	47	130	0.2	83,000	73	867	1.3
Toluene	520	120	18	0.02	59,000	170	120	0.13
bis(2-ethylhexyl) phthalate	16,000	310	0.8	0.1	140,000	380	5.3	0.67
Carcinogenic polynuclear aromatic hydrocarbons (total) ^d	74,900	74,900	ND	ND	74,900	47,800	ND	ND
Polychlorinated biphenyls (total)	3,400	2,040	ND	ND	2,270	2,270	ND	ND
	<u>(mg/kg)</u>	<u>(mg/kg)</u>			<u>(mg/kg)</u>	<u>(mg/kg)</u>		
Cadmium	700	2	0.03	0.03	110	2	0.2	0.2
Nickel	530	14	0.2	0.07	300	15	1.3	0.47
Chromium (total)	4,300	15	0.09	0.09	250	12	0.6	0.6
Arsenic	19	8	0.3	0.04	36	9	2.0	0.27
Zinc	63,000	69	0.4	0.08	3,000	56	2.7	0.53
Cyanide, total	1,920	26	1.3	0.18	111	12	8.7	1.2

TABLE 38
(continued)

MAXIMUM AND AVERAGE EXPOSURE POINT CONCENTRATIONS
OF CONTAMINANTS FOR RECEPTOR DOSE CALCULATIONS

Notes

- a Sources of data for this exposure pathway included surface soil samples collected during Round 1 and soil boring samples at 0 to 2 feet depth collected during Rounds 1 and 2. Since all of the surface soil samples were collected from a small area of the WRR site, only soil boring data were used for geometric mean calculations. Maximum values for each indicator chemical were obtained from either surface or subsurface soil data.
- b Highest values from groundwater data collected during Rounds 1 and 2 were selected. These values were then multiplied by a dilution factor of 1/200 (municipal water supply) and 1/30 (private well water) to estimate concentrations which may occur at points of receptor contact. Refer to Section 3 for an explanation of the dilution factors.
- c Highest values from soil boring data at all depths collected during Rounds 1 and 2 were selected.
- d Includes only compounds classified as human or possible human carcinogens by the International Agency for Research on Cancer. Values for these compounds were summed within each sample.

ND - not detected

TABLE 39

ESTIMATES OF MEDIA INTAKE AND SELECTED EXPOSURE FACTORS

<u>Population (age range)</u>	<u>Body Weight (kg)</u>	<u>Water Consumption (l/d)</u>	<u>Inhalation Rate (m³/hr)</u>	<u>Skin Surface Area (cm²)</u>		<u>Soil Ingestion (kg/d)</u>	<u>Maximum Soil Accumulation on skin (mg/cm²)</u>
				<u>Available for Water Contact</u>	<u>Available for Soil Contact</u>		
Adult (21-70)	70	2.0	1.3	18,200	3,890 ^a	1 x 10 ⁻⁴	1.5
Adolescent (6-20)	57	2.0	1.3	18,200	9,650 ^b	1 x 10 ⁻⁴	1.5
Toddler (0-5)	14	1.0	1.4	6,030	NA	NA	NA

^aAssumed for construction worker: head, arms and hands exposed.

^bAssumed for trespasser: head, arms, hands and legs exposed.

NA - Not applicable to exposure pathways.

TABLE 40

ESTIMATES OF THE DURATION AND FREQUENCY
OF EXPOSURE TO CONTAMINATED MEDIA

<u>Contaminated Medium</u>	<u>Contaminant Intake Route and Exposure Activity</u>	<u>Exposure Event Duration</u>	<u>Exposure Event Frequency</u>
Groundwater	Ingestion from drinking and cooking	NA	daily, lifetime
	Dermal absorption from bathing	.33 hour/day	1 event/day, 365 days/year, lifetime
	Inhalation from showering	.33 hour/day	1 event/day, 365 days/year, lifetime
Soils	Dermal absorption from direct contact	NA	<u>Trespassers</u>
			1 event/week, 8 months/year, 5 years
			<u>Construction Workers</u>
			1 event/day, 5 days/week, 18 months

NA - not applicable

TABLE 41

MAXIMUM AND AVERAGE DAILY CONTAMINANT DOSES (mg/kg/day)
FOR CALCULATION OF RISK

Current Site Conditions - Exposure of Trespassers to Contaminated Soils

<u>Chemical</u>	<u>Dermal Absorption</u>		<u>Ingestion</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	ND	ND	ND	ND
1,2-Dichloroethene (total)	4.8E-07	3.8E-07	3.3E-09	2.6E-09
Trichloroethene	9.4E-06	1.1E-06	6.5E-08	7.8E-09
Toluene	1.2E-05	2.9E-06	8.6E-08	2.0E-08
bis(2-ethylhexyl) phthalate	3.8E-04	7.4E-06	2.6E-06	5.1E-08
Polynuclear aromatic hydrocarbons	1.8E-03	1.8E-03	1.2E-05	1.2E-05
Polychlorinated biphenyls	8.2E-05	4.9E-05	5.6E-07	3.4E-07
Cadmium	1.7E-04	4.8E-07	1.1E-04	3.3E-07
Nickel	1.3E-04	3.4E-06	8.7E-05	2.3E-06
Chromium (total)	1.0E-03	3.6E-06	7.1E-04	2.5E-06
Arsenic	4.6E-06	1.9E-06	3.1E-06	1.3E-06
Zinc	1.5E-02	1.7E-05	1.0E-02	1.1E-05
Cyanide, total	4.6E-02	6.2E-04	3.2E-04	4.3E-06

TABLE 42

MAXIMUM AND AVERAGE DAILY CONTAMINANT DOSES (mg/kg/day) FOR CALCULATION OF RISK

Future Site Conditions -
Exposure of Columbia City Residents to Contaminated Groundwater
from Municipal Water Supply

<u>Chemical</u>	<u>Ingestion</u>		<u>Dermal Absorption</u>		<u>Inhalation</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	9.4E-04	9.8E-06	1.1E-06	1.2E-08	1.8E-03	2.0E-05
1,2-Dichloroethene (total)	9.4E-03	9.4E-04	1.1E-05	1.1E-06	1.8E-02	1.8E-03
Trichloroethene	4.1E-03	6.3E-06	5.0E-06	7.7E-09	8.4E-03	1.3E-05
Toluene	6.2E-04	6.4E-07	7.2E-07	7.7E-10	1.2E-03	1.3E-06
bis(2-ethylhexyl) phthalate	2.6E-05	3.3E-06	6.1E-08	7.7E-09	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Cadmium	9.9E-07	9.9E-07	2.3E-09	2.3E-09	NA	NA
Nickel	6.4E-06	2.3E-06	1.6E-08	5.3E-09	NA	NA
Chromium (total)	2.9E-06	2.9E-06	6.9E-09	6.9E-09	NA	NA
Arsenic	9.9E-06	1.3E-06	2.3E-08	3.0E-09	NA	NA
Zinc	1.3E-05	2.6E-06	3.0E-08	6.1E-09	NA	NA
Cyanide, total	4.2E-05	5.9E-06	9.8E-08	1.3E-08	NA	NA

TABLE 42
(continued)

MAXIMUM AND AVERAGE DAILY CONTAMINANT DOSES (mg/kg/day) FOR CALCULATION OF RISK

Future Site Conditions -
Exposure of Columbia City Residents to Contaminated Groundwater
from Private Wells

<u>Chemical</u>	<u>Ingestion</u>		<u>Dermal Absorption</u>		<u>Inhalation</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	6.3E-03	6.5E-05	7.3E-06	7.4E-08	1.2E-02	1.3E-04
1,2-Dichloroethene (total)	6.3E-02	6.3E-03	7.3E-05	7.3E-06	1.2E-01	1.2E-02
Trichloroethene	2.7E-02	4.2E-05	3.3E-05	5.1E-08	5.6E-02	8.7E-05
Toluene	4.2E-03	4.3E-06	4.8E-06	5.1E-09	8.0E-03	8.7E-06
bis(2-ethylhexyl) phthalate	1.7E-04	2.2E-05	2.1E-07	2.6E-08	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Cadmium	6.6E-06	6.6E-06	1.5E-08	1.5E-08	NA	NA
Nickel	4.2E-05	1.5E-05	1.1E-07	3.5E-08	NA	NA
Chromium (total)	1.9E-05	1.9E-05	4.6E-08	4.6E-08	NA	NA
Arsenic	6.6E-05	8.7E-06	1.5E-07	2.0E-08	NA	NA
Zinc	8.7E-05	1.7E-05	2.0E-07	4.1E-08	NA	NA
Cyanide, total	2.8E-04	3.9E-05	6.5E-07	8.6E-08	NA	NA

TABLE 43

MAXIMUM AND AVERAGE DAILY CONTAMINANT DOSES (mg/kg/day)
FOR CALCULATION OF RISK

Future Site Conditions -
Exposure of Construction Workers to Contaminated Soils

<u>Chemical</u>	<u>Dermal Absorption</u>		<u>Ingestion</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	4.8E-07	4.8E-07	8.2E-09	8.2E-09
1,2-Dichloroethene (total)	4.9E-03	1.0E-05	8.4E-05	1.7E-07
Trichloroethene	4.9E-03	4.3E-06	8.5E-05	7.4E-08
Toluene	3.5E-03	1.0E-05	6.0E-05	1.7E-07
bis(2-ethylhexyl) phthalate	8.3E-03	2.3E-05	1.4E-04	3.9E-07
Polynuclear aromatic hydrocarbons	4.5E-03	2.8E-03	7.6E-05	4.9E-05
Polychlorinated biphenyls	1.4E-04	1.4E-04	2.3E-06	2.3E-06
Cadmium	6.6E-05	1.2E-06	1.1E-04	2.0E-06
Nickel	1.8E-04	8.9E-06	3.1E-04	1.5E-05
Chromium (total)	1.5E-04	7.1E-06	2.5E-04	1.2E-05
Arsenic	2.1E-05	5.4E-06	3.7E-05	9.2E-06
Zinc	1.8E-03	3.3E-05	3.1E-03	5.7E-05
Cyanide, total	6.6E-03	7.1E-04	1.1E-04	1.2E-05

TABLE 44

SUBCHRONIC HAZARD INDEX SCORES

Chemical	Soil - Ingestion				Soil - Dermal Absorption			
	Trespassers		Construction Workers		Trespassers		Construction Workers	
	Max	Ave	Max	Ave	Max	Ave	Max	Ave
Vinyl Chloride	ND	ND	8.2E-06	8.2E-06	ND	ND	4.8E-04	4.8E-04
1,2-Dichloroethene (total)	4.2E-08	3.3E-08	1.1E-03	2.2E-06	6.1E-06	4.8E-06	6.2E-02	1.3E-04
Trichloroethene	2.4E-06	2.9E-07	3.1E-03	2.7E-06	3.5E-04	4.1E-05	1.8E-01	1.6E-04
Toluene	2.1E-07	5.0E-08	1.5E-04	4.3E-07	3.0E-05	7.3E-06	8.8E-03	2.5E-05
bis(2-ethylhexyl) phthalate	1.3E-04	2.5E-06	7.0E-03	1.9E-05	1.9E-02	3.7E-04	4.2E-01	1.2E-03
Polynuclear aromatic hydrocarbons	ID	ID	ID	ID	ID	ID	ID	ID
Polychlorinated biphenyls	1.8E-03	1.1E-03	7.7E-03	7.7E-03	2.7E-01	1.6E-01	4.7E-01	4.7E-01
Cadmium	2.2E-01	6.6E-04	2.2E-01	4.0E-03	3.4E-01	9.6E-04	1.3E-01	2.4E-03
Nickel	4.3E-03	1.1E-04	1.5E-02	7.5E-04	6.5E-03	1.7E-04	9.0E-03	4.5E-04
Chromium (total)	3.5E-02	1.2E-04	1.3E-02	6.0E-04	5.0E-02	1.8E-04	7.5E-03	3.6E-04
Arsenic	3.1E-03	1.3E-03	3.7E-02	9.2E-03	4.6E-03	1.9E-03	2.1E-02	5.4E-03
Zinc	5.0E-02	5.5E-05	1.6E-02	2.9E-04	7.5E-02	8.5E-05	9.0E-03	1.7E-04
Cyanide, total	1.6E-02	2.2E-04	5.5E-03	6.0E-04	2.3E-02	3.1E-02	3.3E-01	3.6E-02

ID - Insufficient data in scientific literature to enable calculation.

TABLE 44
(continued)

SUBCHRONIC HAZARD INDEX SCORES

Chemical	<u>Groundwater - Ingestion</u> <u>Municipal Water Users</u>		<u>Groundwater - Dermal Absorption</u> <u>Municipal Water Users</u>		<u>Groundwater - Inhalation</u> <u>Municipal Water Users</u>	
	Max	Ave	Max	Ave	Max	Ave
Vinyl Chloride	9.4E-01	9.8E-03	1.1E-03	1.2E-05	1.8E+00	2.0E-02
1,2-Dichloroethene	1.2E-01	1.2E-02	1.4E-04	1.4E-05	2.8E-01	2.8E-02
Trichloroethene	1.5E-01	2.3E-04	1.9E-04	2.9E-07	3.1E-01	4.8E-04
Toluene	1.6E-03	1.6E-06	1.8E-06	1.9E-09	1.2E-03	1.3E-06
bis(2-ethylhexyl) phthalate	1.3E-03	1.7E-04	3.1E-06	3.9E-07	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Cadmium	2.0E-03	2.0E-03	4.6E-06	4.6E-06	NA	NA
Nickel	3.2E-04	1.2E-04	8.0E-07	2.7E-07	NA	NA
Chromium (total)	1.5E-04	1.5E-04	3.5E-07	3.5E-07	NA	NA
Arsenic	9.9E-03	1.3E-03	2.3E-05	3.0E-06	NA	NA
Zinc	6.5E-05	1.3E-05	1.5E-07	3.1E-08	NA	NA
Cyanide, total	2.1E-03	3.0E-04	4.9E-06	6.5E-07	NA	NA

NA - Not applicable
ND - Not detected

TABLE 44
(continued)

SUBCHRONIC HAZARD INDEX SCORES

<u>Chemical</u>	<u>Groundwater - Ingestion</u> <u>Private Well Waters Users</u>		<u>Groundwater - Dermal Absorption</u> <u>Private Well Water Users</u>		<u>Groundwater - Inhalation</u> <u>Private Well Water Users</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	6.3E+00	6.5E-02	7.3E-03	8.0E-05	1.2E+01	1.3E-01
1,2-Dichloroethene	8.0E-01	8.0E-02	9.3E-04	9.3E-05	1.9E+00	1.9E-01
Trichloroethene	1.0E-01	1.5E-03	1.3E-03	1.9E-06	2.1E+00	3.2E-03
Toluene	1.1E-02	1.1E-05	1.2E-05	1.3E-08	8.0E-03	8.7E-06
bis(2-ethylhexyl) phthalate	8.7E-03	1.1E-03	1.1E-05	1.3E-06	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Cadmium	1.3E-02	1.3E-02	3.1E-05	3.1E-05	NA	NA
Nickel	2.1E-03	8.0E-04	5.3E-06	1.8E-06	NA	NA
Chromium (total)	1.0E-03	1.0E-03	2.3E-06	2.3E-06	NA	NA
Arsenic	6.6E-02	8.7E-03	1.5E-04	2.0E-05	NA	NA
Zinc	4.3E-04	8.7E-05	1.0E-06	2.1E-07	NA	NA
Cyanide, total	1.4E-02	2.0E-03	3.3E-05	4.3E-06	NA	NA

NA - Not applicable
ND - Not detected

TABLE 45

CHRONIC HAZARD INDEX SCORES^a

<u>Chemical</u>	<u>Groundwater - Ingestion</u> <u>Municipal Water Users</u>		<u>Groundwater - Dermal Absorption</u> <u>Municipal Water Users</u>		<u>Groundwater - Inhalation</u> <u>Municipal Water Users</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
1,2-Dichloroethylene	1.2E-01	1.2E-01	1.4E-03	1.4E-04	2.3E+00	2.3E-01
Toluene	2.1E-03	2.1E-06	2.4E-06	2.6E-09	1.2E-03	1.3E-06
Cadmium	2.0E-03	2.0E-03	4.6E-06	4.6E-06	NA	NA
Nickel	3.2E-04	1.2E-04	8.0E-07	2.7E-07	NA	NA
Chromium (VI)	5.8E-04	5.8E-04	1.4E-06	1.4E-06	NA	NA
Zinc	6.5E-05	1.3E-05	1.5E-07	3.1E-08	NA	NA
Cyanide, total	2.1E-03	3.0E-04	4.9E-06	6.5E-07		
<u>Chemical</u>	<u>Groundwater - Ingestion</u> <u>Private Well Water Users</u>		<u>Groundwater - Dermal Absorption</u> <u>Private Well Water Users</u>		<u>Groundwater - Inhalation</u> <u>Private Well Water Users</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
1,2-Dichloroethylene	7.9E+00	7.9E-01	9.3E-03	9.3E-04	1.5E+01	1.5E+00
Toluene	1.4E-02	1.4E-05	1.6E-05	1.7E-08	8.0E-03	8.7E-06
Cadmium	1.3E-02	1.3E-02	3.1E-05	3.1E-05	NA	NA
Nickel	2.1E-03	8.0E-04	5.3E-06	1.8E-06	NA	NA
Chromium (VI)	3.9E-03	3.9E-03	9.2E-06	9.2E-06	NA	NA
Zinc	4.3E-04	8.7E-05	1.0E-06	2.1E-07	NA	NA
Cyanide, total	1.4E-02	2.0E-03	3.3E-05	4.3E-06	NA	NA

^a Chronic hazard indices were not calculated for trespassers and construction workers (subchronic exposure). Also, chronic hazard indices were calculated only for compounds not carcinogenic under indicated exposure pathways.

NA - Not applicable

TABLE 46
CANCER RISKS

Chemical	Soil - Ingestion				Soil - Dermal Absorption			
	Trespassers		Construction Workers		Trespassers		Construction Workers	
	Max	Ave	Max	Ave	Max	Ave	Max	Ave
Vinyl Chloride	ND	ND	1.9E-08	1.9E-08	ND	ND	1.1E-06	1.1E-06
Trichloroethylene	7.2E-10	8.6E-11	9.4E-07	8.1E-10	1.0E-07	1.2E-08	5.4E-05	4.7E-08
bis(2-ethylhexyl) phthalate	3.6E-08	7.1E-10	2.0E-06	5.5E-09	5.3E-06	1.0E-07	1.2E-04	3.2E-07
Polynuclear aromatic hydrocarbons	1.4E-04	1.4E-04	0.7E-04	5.6E-04	2.1E-02	2.1E-02	5.2E-02	3.2E-02
Polychlorinated biphenyls	4.3E-06	2.6E-06	1.8E-05	1.8E-05	3.3E-04	3.8E-04	1.1E-03	1.1E-03
Arsenic	5.6E-06	2.3E-06	6.7E-05	1.7E-05	8.3E-06	3.4E-06	3.8E-05	9.7E-06

Chemical	Groundwater - Ingestion Municipal Water Users		Groundwater - Dermal Absorption Municipal Water Users		Groundwater - Inhalation Municipal Water Users	
	Max	Ave	Max	Ave	Max	Ave
Vinyl Chloride	2.2E-03	2.3E-05	2.5E-06	2.8E-08	5.3E-04	5.9E-06
Trichloroethylene	4.5E-05	6.9E-08	5.5E-08	8.5E-11	1.1E-04	1.6E-08
bis(2-ethylhexyl) phthalate	3.6E-07	4.6E-08	8.5E-10	1.1E-10	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Arsenic	1.8E-05	2.3E-06	4.1E-08	5.4E-09	NA	NA

NA - Not applicable
ND - Not detected

TABLE 46
(continued)

CANCER RISKS

<u>Chemical</u>	<u>Groundwater - Ingestion</u> <u>Private Well Water Users</u>		<u>Groundwater - Dermal Absorption</u> <u>Private Well Water Users</u>		<u>Groundwater - Inhalation</u> <u>Private Well Water Users</u>	
	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>	<u>Max</u>	<u>Ave</u>
Vinyl Chloride	1.8E-05	1.8E-05	1.7E-05	1.8E-07	3.5E-03	3.9E-05
Trichloroethylene	1.8E-07	4.6E-07	3.7E-07	5.6E-10	<u>7.3E-04</u>	<u>1.1E-06</u>
bis(2-ethylhexyl) phthalate	<u>2.4E-06</u>	<u>3.1E-07</u>	<u>4.3E-09</u>	<u>3.6E-10</u>	NA	NA
Polynuclear aromatic hydrocarbons	ND	ND	ND	ND	NA	NA
Polychlorinated biphenyls	ND	ND	ND	ND	NA	NA
Arsenic	1.2E-04	1.6E-05	2.8E-07	3.6E-08	NA	NA

TABLE 47

MAXIMUM (M) AND AVERAGE (A) SUBCHRONIC HAZARD INDICES (≥ 0.01)
FOR NON-CARCINOGENIC EFFECTS

<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Hazard</u> <u>Index</u> <u>(>0.01)</u>	<u>Pathway</u> <u>Hazard</u> <u>Index</u>
<u>Current Site Conditions</u>				
Site Receptors (Trespassers)	Dermal absorption	bis(2-ethylhexyl) phthalate	0.019(M)	3.05(M) 0.19(A)
		Polychlorinated Biphenyls	0.27(M) 0.16(A)	
		Cadmium	0.34(M)	
		Chromium (total)	0.05(M)	
		Zinc	0.075(M)	
		Cyanide, total	2.3 (M) 0.031(A)	
	Ingestion	Cadmium	0.22(M)	0.32(M)
		Chromium	0.035(M)	
		Zinc	0.05(M)	
		Cyanide, total	0.016(M)	

TABLE 47
(continued)

<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Hazard</u> <u>Index</u> <u>(>0.01)</u>	<u>Pathway</u> <u>Hazard</u> <u>Index</u>
<u>Future Site Conditions</u>				
Groundwater (Municipal water users)	Ingestion	Vinyl Chloride	0.94(M)	1.21(M) 0.012(A)
		1,2-Dichloroethene	0.12(M) 0.012(A)	
		Trichloroethene	0.15(M)	
	Dermal absorption	-- none identified --		
	Inhalation	Vinyl Chloride	1.8(M) 0.02(A)	2.4(M) 0.048(A)
		1,2-dichloroethene	0.28(M) 0.028(A)	
		Trichloroethene	0.31(M)	
Groundwater (Private well water users)	Ingestion	Vinyl Chloride	6.3(M) 0.065(A)	8.20(M) 0.16(A)
		1,2-Dichloroethene (total)	0.8(M) 0.08(A)	
		Trichloroethene	1.0(M)	
		Toluene	0.011(M)	
		Cadmium	0.013(M) 0.013(A)	
		Arsenic	0.066(M)	

TABLE 47
(continued)

<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Hazard</u> <u>Index</u> <u>(>0.01)</u>	<u>Pathway</u> <u>Hazard</u> <u>Index</u>
		Cyanide, total	0.014(M)	
	Dermal absorption		-- none identified --	
		Vinyl Chloride	12.0(M) 0.13(A)	0.32(A)
		1,2-Dichloroethene (total)	1.9(M) 0.19(A)	
		Trichloroethene	2.1(M)	
Soils (Construction workers)	Dermal absorption	1,2-Dichloroethene	0.062(M)	1.61(M) 0.51(A)
		Trichloroethene	0.18(M)	
		bis(2-ethylhexyl) phthalate	0.42(M)	
		Polychlorinated Biphenyls	0.47(M) 0.47(A)	
		Cadmium	0.13(M)	
		Arsenic	0.021(M)	
		Cyanide, total	0.33(M) 0.036(A)	
	Ingestion	Cadmium	0.22(M)	0.30(M)
		Nickel	0.015(M)	

TABLE 47
(continued)

<u>Environmental Medium (Receptors)</u>	<u>Pathway</u>	<u>Indicator Chemical</u>	<u>Hazard Index (>0.01)</u>	<u>Pathway Hazard Index</u>
		Chromium	0.013(M)	
		Arsenic	0.037(M)	
		Zinc	0.016(M)	

TABLE 48

MAXIMUM (M) AND AVERAGE (A) CHRONIC HAZARD INDICES (≥ 0.01)
FOR NON-CARCINOGENIC EFFECTS

<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Hazard</u> <u>Index</u> <u>(>0.01)</u>	<u>Pathway</u> <u>Hazard</u> <u>Index</u>
<u>Current Site Conditions</u>				
Surface Soils (Trespassers)	Dermal Absorption		-- not applicable --	
	Ingestion		-- not applicable --	
<u>Future Site Conditions</u>				
Groundwater (Municipal water users)	Ingestion	1,2-Dichloroethene	1.2 (M) 0.12(A)	1.2 (M) 0.12(A)
	Dermal absorption		-- none identified --	
	Inhalation	1,2-Dichloroethene	2.3 (M) 0.23(A)	2.3 (M) 0.23(A)
Groundwater (Private well water users)	Ingestion	1,2-Dichloroethene	7.9 (M) 0.79(A)	7.93 (M) 0.80(A)
		Toluene	0.014(M)	
		Cadmium	0.013(M) 0.013(A)	
	Dermal absorption		-- none identified --	
	Inhalation	1,2-Dichloroethene	15.0(M) 1.5(A)	15.0 (M) 1.5 (A)

TABLE 48
(continued)

<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Hazard</u> <u>Index</u> <u>(>0.01)</u>	<u>Pathway</u> <u>Hazard</u> <u>Index</u>
Soils (Construction Workers)	Dermal absorption		-- not applicable --	
	Ingestion		-- not applicable --	

TABLE 49

ESTIMATED LIFETIME CANCER RISK ($>10^{-7}$) ASSOCIATED WITH
 MAXIMUM (M) AND AVERAGE (A) EXPOSURES TO CARCINOGENS FOR
 EXPOSURE PATHWAY OF CONCERN AT THE WRR SITE

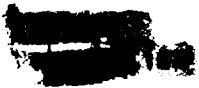
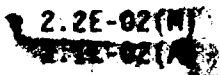

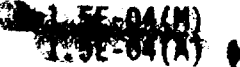
<u>Environmental Medium</u> <u>(Receptors)</u>	<u>Pathway</u>	<u>Indicator</u> <u>Chemical</u>	<u>Cancer Risk</u> <u>$>10^{-7}$</u>	<u>Pathway</u> <u>Risk</u>
<u>Current Site Conditions</u>				
<u>Surface Soils -</u> <u>(Residential)</u>		Trichloroethene	1.0E-07(M)	 2.2E-02(M) 1.1E-02(A)
		bis(2-ethylhexyl) phthalate	5.3E-06(M) 1.0E-07(A)	
		PAHs	2.1E-02(M) 2.1E-02(A)	
		PCBs	6.3E-04(M) 3.8E-04(A)	
		Arsenic	8.3E-06(M) 3.4E-06(A)	
		PAHs	1.4E-04(M) 1.4E-04(A)	 1.5E-04(M) 1.5E-04(A)
		PCBs	4.3E-06(M) 2.6E-06(A)	
		Arsenic	5.6E-06(M) 2.3E-06(A)	

TABLE 49
(continued)

<u>Environmental Medium (Receptors)</u>	<u>Pathway</u>	<u>Indicator Chemical</u>	<u>Cancer Risk >10⁻⁷</u>	<u>Pathway Risk</u>
<u>Future Site Conditions</u>				
Groundwater (Private well water users)		Vinyl Chloride	2.2E-03(M) 2.2E-05(A)	2.2E-03(M) 2.4E-05(A)
		Trichloroethene	4.5E-05(M)	
		bis(2-ethylhexyl) phthalate	3.6E-07(M)	
		Arsenic	1.8E-05(M) 2.3E-06(A)	
	Dermal absorption	Vinyl Chloride	2.5E-06(M)	2.5E-06(M)
	Inhalation	Vinyl Chloride	5.3E-04(M) 5.9E-06(A)	6.4E-04(M) 5.9E-06(A)
		Trichloroethene	1.1E-04(M)	
	Ingestion	Vinyl Chloride	1.5E-02(M) 1.5E-04(A)	1.5E-02(M) 1.7E-04(A)
		Trichloroethene	3.0E-04(M) 4.6E-07(A)	
		bis(2-ethylhexyl) phthalate	2.4E-06(M) 3.1E-07(A)	
		Arsenic	1.2E-04(M) 1.6E-05(A)	
	Dermal Absorption	Vinyl Chloride	1.7E-05(M) 1.8E-07(A)	1.8E-05(M) 1.8E-07(A)
		Trichloroethene	3.7E-07(M)	

TABLE 49
(continued)

<u>Environmental Medium (Receptors)</u>	<u>Pathway</u>	<u>Indicator Chemical</u>	<u>Cancer Risk >10⁻⁷</u>	<u>Pathway Risk</u>
		Arsenic	2.8E-07(M)	
		Vinyl Chloride	3.5E-03(M) 3.9E-05(A)	3.5E-03(M) 4.0E-05(A)
		Trichloroethene	7.3E-04(M) 1.1E-06(A)	
		Vinyl Chloride	1.1E-06(M) 1.1E-06(A)	1.1E-06(M) 1.1E-06(A)
		Trichloroethene	5.4E-05(M)	
		bis(2-ethylhexyl) phthalate	1.2E-04(M) 3.2E-07(A)	
		PAHs	5.2E-02(M) 3.2E-02(A)	
		PCBs	1.1E-03(M) 1.1E-03(A)	
		Arsenic	3.8E-05(M) 9.7E-06(A)	
		Trichloroethene	9.4E-07(M)	9.4E-07(M) 9.4E-07(A)
		bis(2-ethylhexyl)	2.0E-06(M)	
		PAHs	8.7E-04(M) 5.6E-04(A)	
		PCBs	1.8E-05(M) 1.8E-05(A)	
		Arsenic	6.7E-05(M) 1.7E-05(A)	

TABLE 50

MAXIMUM AND MEAN CONCENTRATIONS FOR VOLATILES DETECTED IN GROUNDWATER
 COMPARED TO EPA MAXIMUM CONTAMINANT LEVEL (MCL) FOR DRINKING WATER

Compound(1)	Maximum Concentration (ug/L)	Mean Concentration (ug/L)	Maximum Contaminant Level(2) (ug/L)
<u>Round 1</u>			
Vinyl Chloride(3)	5,500	56	2
Trichloroethene(4)	18,000	18,000	5
<u>Round 2</u>			
Vinyl Chloride(5)	2,800	36	2
1,1-Dichloroethene(6)	92.0	31	7
1,1,1-Trichloroethane	11.0	2	200
Trichloroethene(7)	25,000	38	5
Benzene(8)	7.0	3	5

- (1) Does not include non-detects or compounds for which Drinking Water MCL's do not exist.
- (2) EPA Maximum Contaminant Level Criteria for Drinking Water supply.
- (3) 7 monitoring well samples exceeded MCL (Vinyl Chloride): MW-1S, MW-3S, MW-4S, MW-10S, MW-11S, MW-83A(S), MW-83(D).
- (4) 1 monitoring well sample exceeded MCL (Trichloroethene): MW-9S.
- (5) 11 monitoring well samples exceeded MCL (Vinyl Chloride): MW-1S, MW-3S, MW-4S, MW-8S, MW-9S, MW-10S, MW-11S, MW-12S, MW-14S, MW-83A(D), MW-83A(S).
- (6) 3 monitoring well samples exceeded MCL (1,1-Dichloroethene): MW-3S, MW-9S, MW-10S.
- (7) 1 monitoring well sample exceeded MCL (Trichloroethene): MW-9S.
- (8) 1 monitoring well sample exceeded MCL (Benzene): MW-10S.

TABLE 51

MAXIMUM AND MEAN CONCENTRATIONS FOR ELEMENTS DETECTED IN GROUNDWATER
COMPARED TO EPA MAXIMUM CONTAMINANT LEVELS

<u>Element(1)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Mean Concentration (ug/L)</u>	<u>Maximum Contaminant Level(2) (ug/L)</u>
<u>Round 1</u>			
Arsenic	57.1(3)	7	50
Cadmium	5.0	5	10
Chromium, total	17.0	17	50
Lead	12.0	12	50
<u>Round 2</u>			
Arsenic	23.4	7	50
Chromium, total	6.9	7	50
Lead	2.3	2	50
Selenium	2.2	2	10
Silver	4.1	4	50

(1) Does not include non-detects or elements for which drinking water quality criteria do not exist.

(2) Environmental Protection Agency Maximum Contaminant Level (MCL) for drinking water.

(3) Monitoring Well - 83D (only sample to exceed MCL).

Note: Arsenic was the only element detected in Municipal or Private Water Supply Wells for which EPA MCL's exist (max = 8.6, mean = 7, MCL = 50).

TABLE 52

MAXIMUM AND MEAN CONCENTRATIONS DETECTED IN SURFACE WATER SAMPLES
COMPARED TO EPA AMBIENT WATER QUALITY CRITERIA (AWQC)

<u>Compound(1)</u>	<u>Maximum Concentration (ug/L)</u>	<u>Mean Concentration (ug/L)</u>	<u>AWQC Human (ug/L)</u>	<u>AWQC Aquatic Life (ug/L)</u>
<u>Volatiles</u>				
Methylene Chloride*	6	6	0.19(2)	193,000(3)
trans-1,2-Dichloroethene	1,600	8	---	135,000(3)
<u>Semi-Volatiles</u>				
Diethylphthalate	0.6	0.1	350,000(4)	52,100(3)
Di-n-butylphthalate	0.2	0.2	34,000(4)	940(3)
bis(2-ethylhexyl)phthalate	0.6	0.6	15,000(4)	270(3)

(1) Does not include non-detects or compounds for which Ambient Water Quality Criteria do not exist.

(2) Ambient Water Quality Criteria (AWQC) for carcinogenicity protection (incremental increased lifetime cancer risk of 10^{-6}) in humans ingesting water and organisms.

(3) Ambient Water Quality Criteria (AWQC) for protection of aquatic life (lowest reported toxic concentration, acute).

(4) Ambient Water Quality Criteria (AWQC) for protection of humans ingesting water and organisms, for toxicity protection.

* SW-10 only location to exceed AWQC (Methylene Chloride) for humans.